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1948

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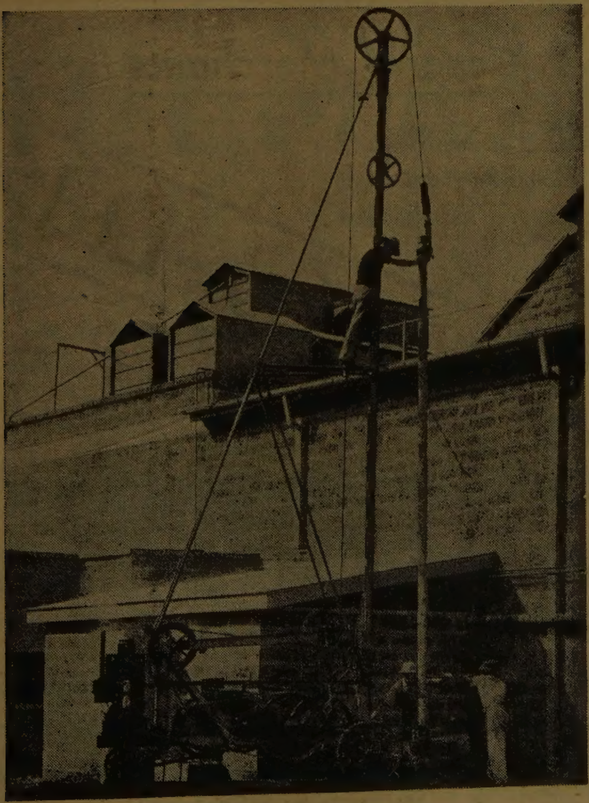

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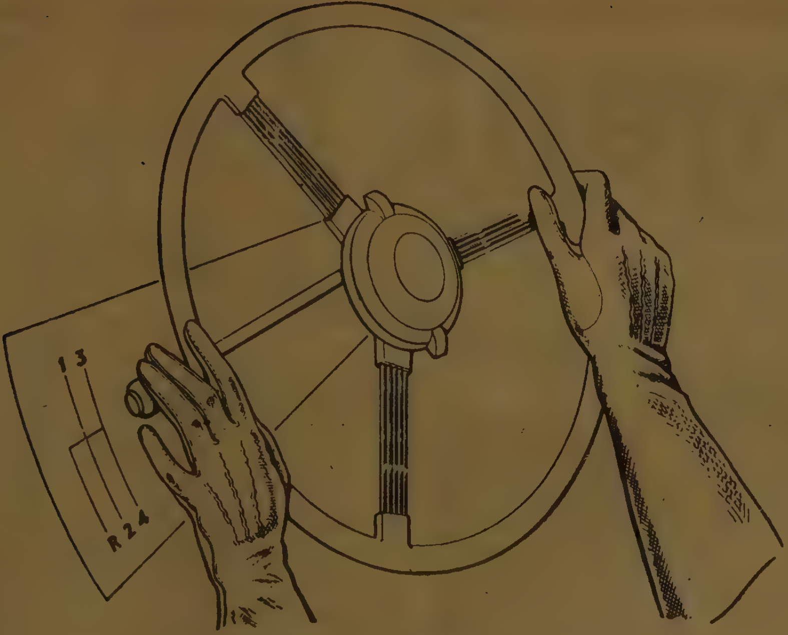

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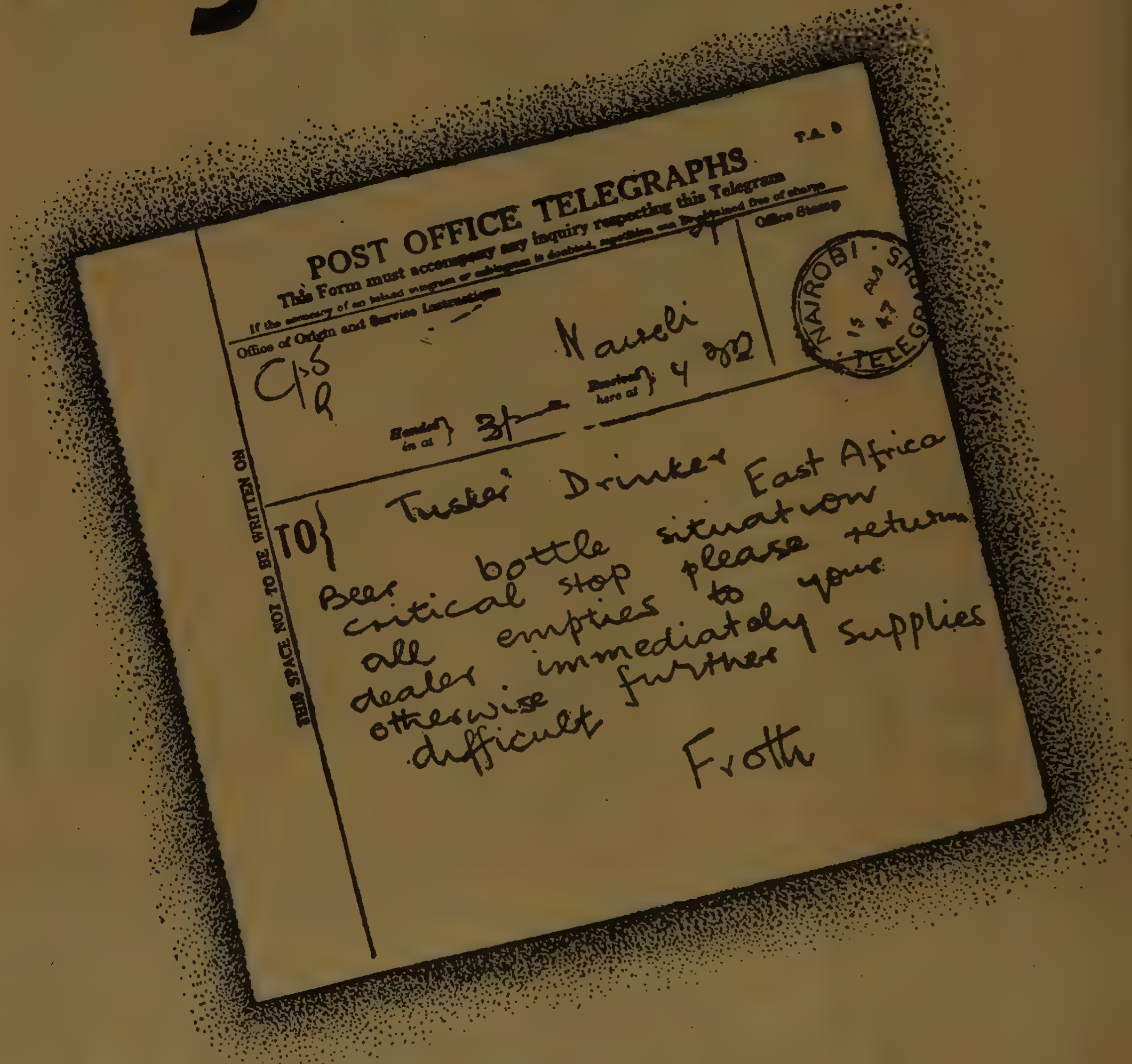

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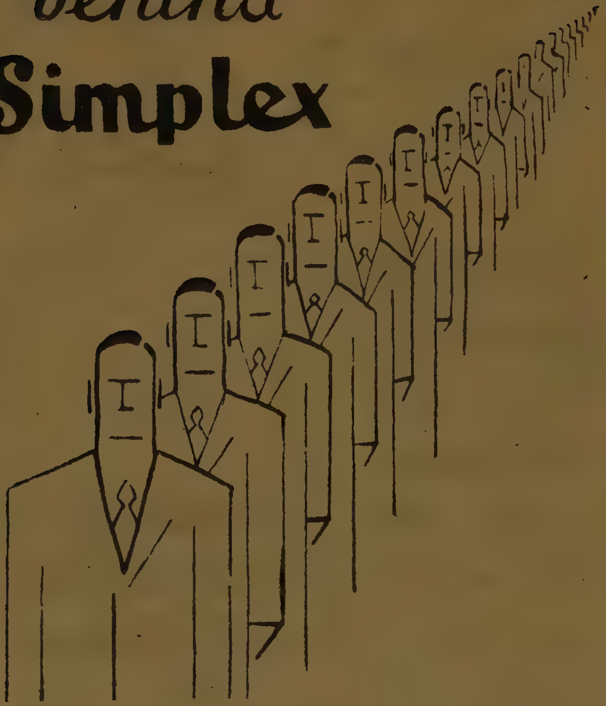

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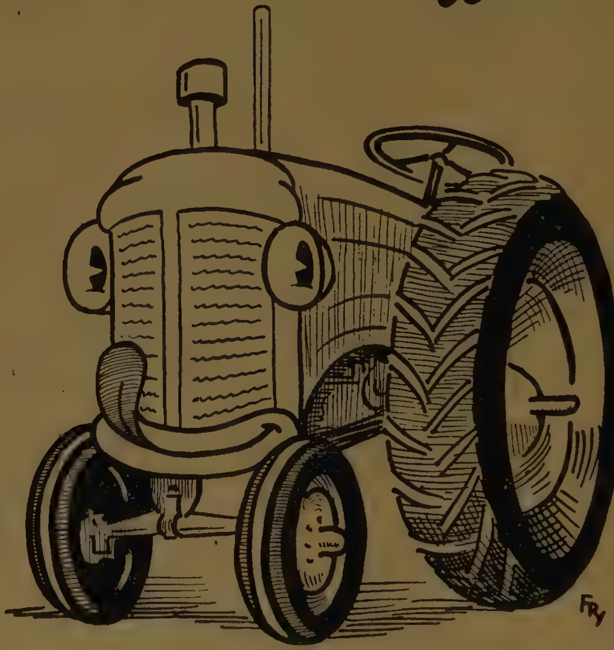

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TRYPANOSOMIASIS AND LAND USAGE

In this number, Ford, Whiteside and Culwick give an interesting discussion on the problems of sleeping sickness in man and trypanosomiasis in stock. Culwick is studying the causal organism in order to find methods of cure and prevention, Whiteside is studying the tsetse fly, which carries the trypanosomes, and Ford is studying the present ecology of tsetse-infested areas in comparison with what knowledge is available on their ecological history. These three widely separated lines of work have a common objective—the finding of practical methods of preventing the spread of the disease into areas which are now free from it, and of eliminating the disease from the vast tracts of Africa in which trypanosomes are the limiting factor in development.

The authors emphasize that trypanosomiasis—*not* the tsetse fly—is the limiting factor, since the presence of the fly itself does not necessarily imply the presence of trypanosomes, although the two are usually associated. If Culwick could protect the victim by preventing the trypanosomes from living in the blood, or if Whiteside could find how to prevent the fly from carrying the trypanosomes, the presence of tsetse flies would become merely a discomfort, not a danger. Thus, although at present eradication of the fly seems the safest solution to the problem it is not necessarily the only solution.

The importance of the possibility that the disease may be prevented without eradication of the vector lies in the fact that in order to create a fly-free area a major ecological change may be necessary, and the effects of this are difficult to judge beforehand. Even the large areas to be cleared by the Groundnut Scheme will merely be ecological islands which are not likely to have a major effect on the vast tsetse-infested areas of Africa, but if the ultimate objective—the eradication of trypanosomiasis from the whole of Africa—cannot be attained without ecological disruption, the greatest caution will be necessary in applying drastic methods on a very large scale.

The ecological implications of this long-range problem are of vital importance to agricultural development, since the system of land usage may have to be adapted to suit the ecological requirements of fly-prevention. Ford brings out examples of how failure to appreciate the relationship between land usage and trypanosomiasis has caused great increases in the incidence of the disease, and one of these is of particular interest. He refers to a paper by Curson, in which it is recorded that the incidence of *Glossina pallidipes* greatly increased in a district of Zululand after it was thrown open to European settlement. Thousands of acres were cleared of bush and put under sugar cane, and it might have been thought that this widespread clearing would have eradicated the fly. But Curson points out that in bush clearing only that land which is suitable for ploughing is stumped, dongas and streams being left untouched. Tsetse flies continue to occupy these strips, and cattle consequently become infected, either when at work near or when grazing along these wooded belts. The effects of European settlement in Zululand are summarized as follows: a small European population generally replaces a large native population; the Europeans bring with them cattle far in excess of those formerly grazing in the area; large game is destroyed on the settlement; native cultivation, which is usually carried out along the banks of streams, is replaced by large-scale cultivation in the open veld, but the bush lining the valleys is left untouched, as it is too expensive to clear and stump; veld fires, which temporarily check the growth of bush, are controlled and bush vegetation spreads; fencing tends to preserve tree growth; overgrazing favours the growth of species of *Acacia* and *Celastrus* (= *Gymonosporia*), which are not eaten by cattle or sheep; movement of men and stock throughout the area is greatly increased, with the result that tsetse flies are carried more rapidly from place to place, and infected stock act as centres for fresh outbreaks.

Since the bush-lined watercourses are the main cause of persistence of the fly, the obvious remedy would be to keep these free from trees, but this would be contrary to the principles of soil and water conservation. Thus it may be difficult to apply the practices of fly-prevention along with those of good land usage, but it should often be possible to apply the principles of both. In this instance the aim would be to protect the streams by a vegetative association which is unfavourable to the fly, possibly by selective clearing.

Whatever the most suitable method of prevention of trypanosomiasis may be, it is almost certain that carefully controlled land usage must be an integral part of any development plan. Kirkpatrick (this Journal Vol. 2, p. 412) even suggests that the tsetse fly has been a blessing in disguise, in that it has prevented wholesale exploitation of vast tracts of relatively poor soils by the wasteful native practices, which he considers are now out of date. Lewis (this Journal Vol. 7, p. 188) criticizes this view as tending to encourage a complacent and *laissez-faire* atttitude towards the spread of fly, but Kirkpatrick's view may also be interpreted as meaning that the presence of tsetse flies in two-thirds of tropical Africa will make necessary a complete change in native agricultural practice. Scattered native holdings are a danger to the community in that they permit the spread of fly, and organized native cultivation is essential if preventive measures are to be successful.

The sleeping sickness settlements which have been set up in several fly-infested districts show that by organized native settlement it is possible to provide homes for large numbers of men and stock who would otherwise have to move to other areas. Yet the sleeping sickness settlement is a palliative rather than a cure, since it is based on the customary native methods of agriculture which require a large acreage per head of population. A drastic change is needed in the methods of land usage by natives, so that permanent intensive cultivation can replace the present shifting cultivation. While it may be difficult to find an efficient farming system which will fit the economics of tribal life, it must not be forgotten that a similar problem was solved by the farmers in Britain. In a recent address to the Nairobi Scientific and Philosophical Society on primitive agriculture, Keen showed this when he said: "Taking as an example the early British agriculture of the 'Three Field System', this long-established organization was completely supplanted not so much by the Enclosure Acts as by the technical advances which they permitted. The stability of the rural organization, with its merry traditions of Michaelmas and Mayday feasts, has given rise to nostalgic misconceptions of the 'contented village life'. The grievous agricultural inefficiency of the Three Field System caused village life to be dominated by recurrent fears of famine. The feasts arose out of the need to slaughter stock at the onset of winter, since there was no provision for winter stockfeed, and out of the communal relief at survival after each winter's scarcity. Change was almost impossible, for the annual redistribution of strips removed all individual interest in the land, while no new crops or improved stock could be introduced into the large communal fields and village flocks".

Keen goes on to give the main points in the change of agricultural practice which revolutionized British farming: "The introduction of turnips for winter keep avoided the seasonal slaughter of stock; the sowing of clover leys improved the soil and vastly increased the productivity of the pastures, while individual attention was given to the improvement of live stock by selection and breeding". These changes did not take place overnight, and it is reasonable to compare with them the present-day efforts of the technical departments in East Africa, since they are based on the same general principles. The growing of cassava as a "storage crop" is being encouraged as an insurance against famine, and hybrids immune or resistant to the two virus diseases, mosaic and brown streak, are being sought by inter-specific crossing. The improvement of range pastures and of temporary grass leys is receiving high priority in all territories; and the grading up of native stock, with retention of hardiness, has shown that great improvements are possible, even with native stockowners.

Since the relationship between land usage and trypanosomiasis is the key to development in two-thirds of tropical Africa, the work of the tsetse research teams should not be regarded merely as a medico-entomological investigation. It is almost certain to be a prelude to the betterment of African agriculture, and its progress should be watched by those who are responsible for the welfare of the native agriculturist. At present the prevention of trypanosomiasis is based on widespread clearing, but Ford, Whiteside and Culwick may produce observations and results which will alter the method of protection. It is to be hoped that they will find a means of eradicating the disease without disturbing the ecological balance, but even if they do, a far-sighted land usage policy will be necessary in order to make the best use of the land which will then be available for development.

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THE TRYPANOSOMIASIS PROBLEM

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In long-range research it is desirable, periodically to review and redefine the problem being investigated, and there are two main reasons for this. First, the fruits of research modify earlier concepts, while secondly, words and phrases alter in usage as thought advances. For this reason we have called this paper "The Trypanosomiasis Problem"—although the phrase most commonly in use is "The Tsetse Problem"—because it seems necessary to reaffirm what is after all a platitude, that the tsetse is only economically important as a vector of trypanosomes, and that the real problem is how to combat the group of human and animal diseases it carries, known collectively as trypanosomiasis. Of this the tsetse problem is part, but only part, and the use of the phrase as a synonym for the larger whole has caused needless misunderstanding and not a little fruitless argument.

There are three main lines of approach to the trypanosomiasis problem. First, there is that through the causal organism, the trypanosome, by a search for cures and for methods of prophylaxis and immunization. Secondly, there is the approach through the vector—the tsetse flies—whose eradication, it is virtually cerain, would lead to the disappearance of the forms of trypanosomiasis economically important in East Africa. Finally, there is the broad ecological approach which seeks so to modify the whole environment that it becomes inimical to the continuance of these diseases.

Each line of approach has its own vehement protagonists, and we, the writers of this paper, are each primarily concerned with one of them. But let it not be thought that any of us is the advocate of one method to the exclusion of any other: on the contrary, our intention is to demonstrate that they are merely lines of approach to a common end, each of which may have its uses, perhaps alone, perhaps in combination with one or both of the others.

APPROACH THROUGH THE TRYPANOSOME

Trypanosomes have been found in every class of vertebrate, being transmitted as a rule from one to another by an invertebrate vector. In East Africa, however, there are only half-a-dozen trypanosomes of any economic importance, and in each case the only vector we need consider is the tsetse fly, although mechanical transmission by other biting flies may assume considerable importance under certain conditions and presents its problems which also call for investigation.

Trypanosoma gambiense causes sleeping sickness in man in some parts of Uganda and Kenya, while in much of Tanganyika and in smaller areas of both Kenya and Uganda we find *Trypanosoma rhodesiense* producing, a similar, but far more acute and rapidly fatal, disease. *Trypanosoma brucei*, the third of the polymorphic group, is non-infective to man, but lethal to certain animals, such as dogs, horses and monkeys. On the other hand, although cattle can be infected with both *T. rhodesiense* and *T. brucei*, they can throw off the infection after a time if they are well maintained, appearing to suffer no permanent ill-effects (Wilde and French [1]). *Trypanosoma congolense*, however, is lethal to them. *Trypanosoma vivax* is said to be less virulent to cattle than *T. congolense* (Hornby [2]), but it causes losses of sheep, is virulent to horses and often causes death in goats. *Trypanosoma simiæ* is well described as the lightning destroyer of the domestic pig.

Just as different species of trypanosomes differ in their action on their hosts, so they vary in their responses to different drugs. However, drugs are known which will cure most forms of East African trypanosomiasis in their early stages, though, at least in infections by the polymorphic trypanosomes, once the disease has been established for a certain time—and this varies with the trypanosome and the host—drug treatment produces no lasting effect, and death inevitably occurs. It is held that in such cases a time comes when the trypanosome passes the "blood-brain barrier", and enters the central nervous system where drugs at present in use cannot follow it in adequate concentration. For this reason early diagnosis and treatment of all cases of human trypanosomiasis are essential to recovery. This is certainly a subject on which more research is badly needed, since the solution of the problem of treating late cases would lead to great saving of life, particularly in backward communities where people are inclined to be tardy in bringing their ailments to the doctor's notice.

But although better curative methods are important, the crucial problem is the prevention of infection. The eradication of the insect vector, the tsetse fly, is an obvious method; but this may not prove economically practicable in many places for a long time to come, and one naturally inquires whether there are not other possibilities. Two such suggest themselves. Since the tsetse carries the disease from mammal to mammal, we can theoretically break the chain of infection at one of two points—we can prevent infected mammals from infecting clean flies, or we can prevent infected flies from infecting clean mammals.

Every animal with trypanosomes in its blood stream is a potential source of infection to the tsetse fly, and therefore a danger to man and his beasts. The chief reservoir of trypanosomes in East Africa is neither man nor yet his stock, but the wild fauna of the country, and there can be no reasonable doubt that the elimination of this reservoir would greatly reduce trypanosomiasis in stock, and probably also in man. Some workers have doubted whether wild game can be a reservoir of *T. rhodesiense*, but recent evidence (Fairbairn and Burtt [3]) shows that it definitely can be and probably is; therefore game is a factor to be reckoned with in any attempts to control sleeping sickness. On the other hand man is, perhaps, the most important reservoir of *T. gambiense*. However, no matter what importance must be placed on different species as trypanosome reservoirs, one thing is certain—healthy men and healthy stock, placed in an area where fly could not pick up trypanosomes from other mammals, would remain healthy. Other things being equal, then, trypanosomiasis should be greatly reduced by eliminating from the neighbourhood of human settlement such wild animals as can carry pathogenic trypanosomes. It should not be forgotten, however, that all animals are not on a par in this respect. Some, such as certain antelope, are a great danger to man as trypanosome reservoirs; others, like the baboon, are not. Yet others occupy an intermediate position. But our knowledge is very incomplete, and a detailed survey of trypanosomiasis in wild animals is urgently required before we can with certainty assess the danger of particular species to man and his stock.

The tsetse fly is, as we have seen, only a danger when it is infected, and various workers have shown that temperature is one factor determining the percentage of flies infected by a host, while Burtt [4] made the important discovery that the temperature at which pupæ are incubated has a marked effect on the fly's chances of becoming infected. His work, which is not yet complete, raises questions of great practical importance. For example, it is possible that certain methods of bush clearing, though reducing the tsetse population, may, by raising soil temperatures, increase the proportion of infected flies, and so produce little, if any, real benefit. Secondly, it opens up the possibility of controlling soil temperatures by encouraging certain types of cover, so that tsetse emerging under these conditions have the minimum chance of later becoming infected and acting as vectors of trypanosomes.

Far more work of this kind, in which the tsetse is studied as a vector of disease, is an urgent necessity to the fuller understanding of our problem. At present, far too many important questions are unanswered. Why for instance, when a large number of tsetse feed on an infected animal, do only a very small though dangerous proportion become infective as a general rule? What determines the degree of metacyclic trypanosome infection in the fly and hence its power of transmitting trypanosomes to mammals on which it feeds? What part is played by the fly's anatomical and physiological make-up, and how does this depend on its habitat? These and other problems must be solved before we can get the clear picture of this first part of the cycle of infection, which is a necessary preliminary to evolving successful preventive methods; and such a picture can only be obtained by the closest co-operation between the entomologist, the insect physiologist, the protozoologist and the epidemiologist, calling in, may be, the assistance of other workers in yet other branches of science.

The other possible place in which the chain of infection can theoretically be broken is between the infected tsetse and the vertebrate. Assuming that we cannot avoid having infected tsetse near human settlement, can we prevent them infecting man and stock? Can we, in short, devise suitable methods of prophylaxis or immunization?

Prophylactic measures have been of considerable value in certain diseases, while immunization has been eminently effective in others, particularly in certain virus diseases:

small-pox and yellow fever are nothing like the problems they used to be, nor are various bacterial infections—typhoid fevers, diphtheria, tetanus and anthrax, for example. But so far, no one has ever produced a practicable method of artificially immunizing any animal against a protozoal infection—and, the trypanosomes are protozoa. This does not, however, justify the counsel of despair one frequently hears from those who consider that past failures imply impossibility. East Coast Fever is a protozoal disease; and yet, as everyone knows, a calf recovering from it becomes immune to further attack, as do rats after recovery from infection by *Trypanosoma lewisi*. Certain types of leishmaniasis are known to produce immunity against the causal organism, as in patients recovered from Oriental Sore. Fairbairn and Burtt [3] have shown that a few men and monkeys have a strong natural resistance to sleeping sickness (*T. rhodesiense*). If then susceptible species can exhibit a natural resistance to a protozoal infection, and if, as in certain cases, an immunity can be acquired naturally why should its artificial production be impossible in the case of the trypanosomes we are concerned with here, particularly as the latter are free-swimming, extra-cellular parasites, exposed to the body fluids and any antibodies that may be produced in them?

The whole problem bristles with difficulties and questions of a highly technical nature. What are trypanosome antigens; what are their chemical and physical properties; how are they formed, and under what conditions; in what does the defence mechanism of the mammal lie; in the polymorphic trypanosomes do all three forms have the same antigenic effect; is polymorphism a genetic phenomenon and if so how is genetic structure related to the effect; what controls strain and species specific antigens? And so on.

And in all this work one is dealing not with one disease, but with several; not with a single species, but with a number of related ones; with microscopic, highly motile organisms, whose behaviour is governed, amongst other things, by electric charges which may change in sign, whose activities will respond to minute fluctuations in their environment. But difficult though the task may be, it is economically vital, and success cannot but pay dividends out of all proportion to the cost incurred.

APPROACH THROUGH THE TSETSE

Originally the entomologist set out to get rid of tsetse altogether, and clearly this must continue to be his main objective, for the invention of simpler and more widely applicable means of clearing land of tsetse is a goal it would be undesirable to abandon, aiming as it does at one of the key solutions to the whole problem. Nor is it a vain aspiration. Napier Bax [5] has summarized recent advances in "tsetse reclamation" and described examples of the successful use of various techniques in East Africa. Glasgow and Duffy [6] at a Tsetse Research Department station in South Kavirondo, recently eliminated a light infestation of *G. palpalis* by hand catching, repeating a method used by Symes and Vane [7] who reduced a similar infestation to such negligible proportions that successful settlement was possible; Morris [8], in the Gold Coast, virtually eliminated, by selective clearing, both *G. palpalis* and *G. tachinoides* from over 1,000 square miles of country. The fact is that a number of ways of tsetse eradication of the type in which the entomologist, by himself produces fly-free country do already exist, and progress is being made in improving them and finding others. On the other hand, in the words of Napier Bax [5], "the goal to be arrived at—the ability to reclaim cheaply *any* kind of country from *any* species of tsetse—has not yet been attained". (The italics are ours.)

This being so, there is good reason for the entomologist faced with the more recalcitrant types of tsetse infestations to consider the potentialities of other lines of attack as well, and this to some extent is already happening. But such a wider approach demands a corresponding broadening of the entomologist's own outlook. We are therefore concerned first to point out how his attention to techniques other than direct extermination may make valuable contributions to the common problem, and to show that he can usefully learn something of the medical and of the broader ecological aspects of trypanosomiasis, consider how they interlock with his own, and base some of his research on discoveries made in these fields.

For instance, there is the discovery to which we have already alluded, made by an entomologist working in a trypanosomiasis laboratory, of the connexion between temperature in the pupal stage and transmission of trypanosomes by the adult fly, which points to a possible means of inhibiting the tsetse's power to transmit disease. Another conceivable way of doing the same thing is to shorten its life, for a certain time must elapse after infection before the fly can begin to transmit (setting aside purely mechanical transmission about which little is known). Can we prevent its living so long? In a recent experiment with D.D.T. at Shinyanga the average age in *G. pallidipes* was apparently halved. Work on these lines, which involves collaboration between protozoologist and entomologist, is about to begin at Shinyanga, and illustrates the extension of aim in entomological work brought about by the attitude we are advocating, for the goal here is not the extermination of the tsetse, but the control of its activities as a vector. There are other lines of equal importance waiting to be explored, such as, for instance, the peculiar differences individuals in apparently uniform batches of tsetse exhibit in their efficiency as vectors of trypanosomes, a problem well worth the careful attention of the insect physiologist.

The potentialities of joint attack on human trypanosomiasis by mass treatment and reduction (as opposed to extermination) of tsetse have been discussed by Morris [8]. He concludes that a "reduced vector potential" coupled with mass treatment by present-day drugs has distinct uses, though probably only where transmission rates are low from one cause or another and where, for entomological reasons, complete eradication is not feasible. He calls for the epidemiological study of such situations, wherein again the entomologist's participation is essential.

It is relatively easy to-day to reduce almost any tsetse infestation to a low level, using traps, fire-exclusion or controlled burning, selective clearing, insecticides, possibly judicious game destruction, and so on, whichever is most appropriate—and in passing, we may note that "biological sterilization"* may provide a way of finishing off some of these reduced populations.

The entomologist is, of course, vitally interested in the *mechanism* of these processes. He seeks to intensify the crucial factors and so to eradicate the fly. But such reduced populations have a wider interest, as forming a weapon in the ecologist's armoury. Essentially, the ecologist seeks to alter in man's favour the natural balance between host, tsetse, trypanosome and environment, and reduction of tsetse tips this balance in the right direction. We shall describe later a situation in Northern Rhodesia where, after a system of optimum land usage had by itself failed to control trypanosomiasis, reducing the tsetse density as well, by direct attack, did so. This type of problem provides scope for entomological inquiry, and raises many important questions. In what way, if any, is tsetse behaviour altered by the human exploitation of bush country; how does a species behave in a partly unfavourable, as opposed to a wholly favourable, environment; is behaviour altered as a result of artificial or natural reduction of tsetse populations?

This suggests another sphere of collaboration between entomologist and ecologist. Variation in structure and habits is an important phenomenon in animal, and particularly in insect, populations. It is usually most noticeable when the insect is abundant, reduction in numbers being accompanied by selection, so that a reduced population often loses some of its previous characteristics and exhibits others in greater or lesser degree. Usually too, reduction from different causes selects different types for survival. Therein, of course, lies the importance of studying artificially reduced populations; while a study of variation under other conditions may throw light on the peculiarly fluctuating and rather sensitive position of tsetse in the ecosystem of which it forms a part. It is possible that some of the great tsetse advances following a comparatively small initial increase of fly may have been due to a greater degree of variation arising as the flies became more numerous, and with it the emergence of previously suppressed potentialities. For this reason, a study of both seasonal and local morphological variation in tsetse is now going on.

These are some of the ways in which the entomologist can, it seems, contribute to the solution of the trypanosomiasis problem, apart from his direct attempts to exterminate the vector. But the original goal remains. It is unwarranted to assume that a creature which is by no means numerous as insects go, which has pronounced vegetational requirements (though these often defy precise description), which produces less than a dozen offspring in its lifetime and, moreover, is completely dependent on encountering a mobile food supply every few days, should be able to resist direct attack indefinitely. One reason why the problem is so difficult is, of course, that the seven most important species of tsetse, which differ markedly in both habitat and behaviour, often require different methods for their control.

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* This means introducing into the habitat of one species another which, while it survives, mates at random with the first, whose females it either renders sterile or causes to produce hybrid offspring, themselves sterile or non-viable.

One of the most promising lines of direct attack involves altering the vegetation in which the fly lives. This does not always lead to extinction, but it usually reduces the fly in an impressive manner. Our methods are still somewhat empirical; in discriminative clearing, for instance, what vegetation is essential to the tsetse is decided by comparing the numbers caught in different parts of the habitat, and by observing how catches of fly are affected by removing different elements. Fundamental distinctions have yet to be made. At Shinyanga the behaviour of the tsetse—its response to different kinds of light, to humidity, temperature, scents, and so on—is being studied in an attempt to find out what conditions it prefers and how it reaches them. It is a lengthy and rather difficult study, but it may enable us to understand something of how environmental control measures work.

One of our greatest difficulties in improving some of the existing methods of eradication is our ignorance of how they produce their effect. How, for instance, does fire-exclusion reduce *G. swynnertoni*? Finding out is no simple matter, but an answer to this question would provide important knowledge likely to lead to further progress. Here the tsetse entomologist needs the co-operation of plant and animal ecologists, for fire-exclusion produces marked changes in both plant and animal life, of which we at present know little. A study of the differential action of predators on tsetse pupæ in various plant communities, which before the war seemed to offer at least a partial explanation, is now being resumed at Shinyanga. So far we know very little of other factors which can affect the numbers of fly directly.

Another promising line of attack is suggested by observations on the recovery of tsetse populations after decimation. This has been observed after such varied methods of attack as trapping, fire-exclusion and D.D.T. have considerably reduced numbers under conditions in which the likelihood of re-infestation from outside has almost certainly been nil. Recovery always stops when the tsetse reach their previous normal density (below which they may have been held artificially for some years) although at present we know of nothing to stop a rising population from reaching comparatively enormous numbers. Clearly then, there exists in nature some powerful, but as yet unknown, factor which begins to operate when the fly reaches a certain density. This, of course, we should expect, for there is no reason to suppose that tsetse differ from other organisms in this respect, although the most common limiting factor, exhaustion of the food supply by the increasing population, does not seem to exist here. There can be little doubt that a greater knowledge of the factors inimical to the growth of tsetse populations would be of great assistance in devising means of control. To acquire this, however, demands new experimental methods. Hitherto our knowledge of tsetse bionomics has been derived by comparatively simple means which no longer suffice—fly rounds, pupa searches, marking experiments, etc.—but to-day these methods largely fail to answer the questions posed as the result of the wider outlook. Therefore, to invent more subtle techniques for use in both the field and in the laboratory is at present one of the most pressing practical tasks of the entomologist who would approach the problem in the way we advocate.

It should be clear from these few examples that there is still plenty of promise in the field of tsetse eradication. This, then, is the entomologist's chief concern. But in addition, there is a wider field in which his contributions are now required, involving him in closer co-operation than before with those working on other approaches to the common problem, and demanding a willingness on his part to view it and examine it from new standpoints.

THE BROAD ECOLOGICAL APPROACH

In this section we wish to cut across the lines of thought contained in the preceding paragraphs. The entomologist and the protozoologist are concerned with individual organisms; they combine studies of the physiology and behaviour of organisms with studies of their environmental requirements. In this third approach to the trypanosomiasis problem we are concerned not with individual organisms but with populations, not with the physiology of infected men or beasts but with their reactions as communities to the situation created by the presence of trypanosomiasis.

And because it is impossible to isolate such communities for comprehensive study in the way we can individual organisms, our first task is to decide what are the essentials we need to know about these communities, and to this end we propose to examine some aspects of the development of the present situation in East Africa.

Napier Bax [5a] suggests that in Tanganyika "the peak years of the slave trade and the first years of the German conquest created conditions favourable for a steady advance of fly". To the depopulations of the slave trade, the Hehe war, the Maji-maji rebellion and the 1914–18 war may be added the devastations of rinderpest and small-pox in the nineties, from which in some areas neither the wild game nor man has yet fully recovered, the mortality around Lake Victoria from *T. gambiense* carried thither during the "scramble", and other events too many to mention. These observations suggest that, through widespread changes in vegetation, themselves dependent not only on soils and climate, but also on changes caused by man's activities (*see*, for example, Thomas [9] on Buganda), the period from 1840 onwards has witnessed the creation throughout East Africa of a vast biological disequilibrium of which the spread of tsetse and trypanosomiasis is but a part.

In Tanganyika disintegration began early, with the internal expansion of the slave trade around 1840, and the Tanganyika tsetse belts may now be approaching their limits, although certain trypanosomes (e.g. *T. rhodesiense*) have yet to reach their maximum distribution. In Uganda, where the impact of disruptive forces came forty years later, the expansion of tsetse belts is in full momentum to-day. In Kenya, though less is known of this aspect of fly advances, Lewis [10] describes events following upon European occupation which have produced similar effects.

It would be wrong, however, to suggest that a decline in human population has been even the main reason for these events. Van Hoof's [11] account of the Semliki Valley, together with what is known of the history of the neighbouring Rift Valley floor around Lake Edward, is an illuminating example of the consequences of failure to appreciate the relation of land-usage to trypanosomiasis. (That in those early days the existence of sleeping sickness was scarcely realized and that therefore no blame can be assigned does not detract from the value of the lesson it should teach.) It is quite clear that this area was occupied by a flourishing mixed population of Bantu agriculturalists and half-Hamite cattle-owners; it is also known that both *G. palpalis*, carrying endemic Gambian sleeping sickness, and *G. pallidipes* (Neave [12]), almost certainly carrying *T. congolense*, were also present, but, obviously, contact was avoided. The Belgian authorities, to facilitate government, moved certain tribes, hitherto living outside the *palpalis* zones, nearer to the administrative centres "which became the most dreadful foci of infection, since it was impossible to approach them from any side without crossing countless streams and marshes infested with tsetse" (District Commissioner Hackaers, quoted by Van Hoof). On the British side, when the epidemic spread, the whole population of the Rift was evacuated, in 1910–13, together with 10,000 head of cattle. When an attempt was made, about 1920, to bring back some of these herds it was found impossible; and to-day the advance of the second tsetse (*G. pallidipes*), initiated when the population was removed, is still in progress many miles from its starting point. (For some of the facts quoted we are indebted to records in the Ankole District Book.)

Van Hoof's example is by no means an isolated one. Curson [13], in Zululand, showed that an indigenous population had developed a form of land-usage which inhibited the formation of fly-belts and permitted cattle to be kept. Their displacement by Europeans using different methods resulted in the spread of fly and nagana. It is suggestive, too, that the technique of sleeping sickness concentrations used in the *morsitans* belts is known to reproduce the type of settlement characteristic of these areas before European "pacification" (Maclean [14]).

Such situations as these, apart from their intrinsic interest, suggest many lines of research. What density of human population is necessary to eliminate tsetse? What forms and distribution of local industry are best suited to avoid contact with the fly? What environmental relationships of human or cattle populations are most favourable to the production of epidemics? What is the effect of changing tsetse habitats on infectivity? Sleeping sickness concentrations provide an especially interesting line of research. The reduction of fly believed to occur around the periphery of these settlements needs investigation not only to find how it comes about, but also for comparison with the parallel, but not necessarily similar, effects to be expected from large-scale projects, such as the Groundnut Scheme, which produce islands in the middle of fly-belts.

From a somewhat different point of view we may consider a developmental scheme carried out near Fort Jameson in Northern Rhodesia. It was believed, not unreasonably, that the development of a fly area based on sound planning in relation to agricultural potentialities of the land, would enable the incoming population so to modify the country that fly would be eliminated. Unfortunately the preliminary stage, in which more people meant more contact between man and fly and hence more rapid spread of pathogenic trypanosomes, was overlooked and sleeping sickness became epidemic. Anti-tsetse measures proposed by the Tsetse Research Department were then applied, and the resulting decrease of fly so reduced contact that the epidemic died down [15].

It would be wrong to generalize from this that fly reduction, or elimination, is an essential preliminary to development. What clearly is essential is a more precise knowledge of the epidemiology of trypanosomiasis, so that we can forecast changes in the incidence of disease when the relations between man and fly are changed. Very little research has been done on these lines between Carpenter's [16] early investigations and Fairbairn's [17] recent demonstration of an apparent relationship between long term cycles of tsetse numbers and sleeping sickness cases recorded over many years in Tanganyika. We are far from understanding these cycles. Nevertheless the recognition of their occurrence over wide areas is of practical importance in forecasting the incidence of disease, while past ignorance of them has sometimes led to mistaken interpretation of the results of reclamation. The possibility that reclamation may be facilitated by correct timing in relation to natural fluctuations of tsetse numbers is still an unexplored field.

Finally, let us return to the notion of trypanosomiasis as an aspect of the general biological equilibrium. Developmental schemes, whatever their immediate object, are attempts to create new equilibria. The measure of their success will depend upon the extent to which the ecology of the whole area is understood. For, just as a purely agricultural approach in the Fort Jameson scheme created an exacerbated trypanosomiasis problem, so straight-forward elimination of tsetse immediately creates problems of land-usage. This latter point of view is stressed by Hornby [2a], who emphasizes that solution of the trypanosomiasis problem in the semi-arid lands of Tanganyika involves not only tsetse eradication but also, by improved pasturing methods, the institution of more stable forms of land-usage; and these are evolved through research in fields quite other than that of trypanosomiasis.

Again, in parts of the *morsitans* belt of Ankole and Bukoba, preliminary observation indicates that much of the settlement in the past occupied precisely the areas which now carry tsetse concentrations. Conversely, tsetse concentrations in the Sukuma *swynnertoni* bush are on hardpan soils which the African peasant has been unable to develop agriculturally. While it might appear in the one to have been a happy chance that made settlement itself an anti-tsetse measure and, in the other, that local land-usage meant avoiding potential tsetse haunts, this apparent fortuitousness is not real at all, for land usage no less than concentration of tsetse is a response to local environment.

While it is difficult to generalize from a few examples there seems no doubt that there is need for operational research into the relationship not only of the problems encountered by different experts in any given area, but also into ways and means of applying the results of research. Thus, while development on purely pastoral lines would appear, in the absence of immunization or adequate prophylaxis, to demand the prior elimination of tsetse, it is possible that development on lines leading to mixed farming or to formation of large scale industries might well go hand in hand with an attack on trypanosomiasis. Indeed, the need for research into the relations between local land usage potentialities, in the widest sense, and the methods of tsetse reclamation is obvious. Here the co-operation which we believe to be essential in the research field is not only between workers primarily engaged on the trypanosomiasis problem, but also between them and research workers in other fields—agriculture, forestry, geology, sociology, and so on. Worthington [18] who envisages something of this sort as a preliminary to his proposed development schemes for Uganda, suggests as the first main factor limiting efforts to increase production the "lack of fundamental information about the country". This cannot be disputed, but more than one worker has carried out a laborious investigation, only to find subsequently and by chance that the information he sought was already available in a dead file of another department. What is involved is not only the amassing of data, which alone are valueless; but also the formulation of hypotheses which can be tested and used as a basis for planning; and this can only be achieved by pooling of knowledge and combined effort.

CONCLUSION

We opened this discussion by emphasizing the necessity of regarding the trypanosomiasis problem as a whole, not only for purposes of definition, but also as being essential to understanding the relationships its various aspects bear to one another. We continued by examining simply what have emerged as the three main approaches to this problem, and we have tried to suggest ways in which they may be co-ordinated.

The contemplated union of tsetse and trypanosomiasis research organizations follows naturally from a recognition of the need of this co-ordination, both in the laboratory and in the field. We feel, however, that this will only fully achieve its object if there is unity of purpose and understanding, not only between workers engaged in tsetse and trypanosomiasis research, but also between them and others concerned with the biological development of Africa. To attain this we believe that a new assessment of the trypanosomiasis problem, with all its many ramifications, is essential. Further, we believe that the co-operation we wish to see between research workers cannot fail to produce results unobtainable in the isolation we hope is now past. These are the motives which have led us to present this paper.

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PLANNING FOR FUEL AND POLE PLANTATIONS

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This article was written originally for Administrative Officers interested in Native Authority afforestation schemes in the Lake and Western Provinces of Tanganyika Territory. It is hoped, however, that it will also be of assistance to other officers establishing fuel plantations at schools, prisons, or experimental stations, and also of interest and help to many farmers. It is intended to give a brief idea of the principles of forest management which should be considered when planning an afforestation scheme, rather than details as to how to do the planting.

POLICY

Before launching out on the planning of an afforestation scheme as envisaged above, the policy to be followed must be decided. The following points should be considered:—

(i) Ownership of the plantation.
(ii) Requirements of the local population.
(iii) Disposal and sale of the produce.

Ownership.—Plantations for the benefit of natives may be made by:—

(*a*) Individual effort, voluntary or compulsory;
(*b*) Communal plantations (an aggregate of compulsory individual ones); or
(*c*) Native Authority plantations established by paid labour.

The ideal would be for each individual or small community to have its complete series of plantations giving a sustained yield. Fairly detailed technical supervision, however, would be required in a great number of areas, even in a single administrative district. As a start, therefore, an example should be set by the Native Authority by establishing a series of plantations at or near its headquarters, the labour being paid at normal rates. These plantations will show what can be grown and how to set about it.

Requirements.—It must also be decided what are the requirements of the people in the vicinity. Usually they need fuel and building poles. Sawn timber may also be required; there certainly will be an increasing demand for timber as the native African progresses. The production of timber for sawing, however, is a long-term process of about a generation, say from 25 to 40 years or even longer. It is therefore work for Government to undertake rather than for individuals or small communities. The Forest Department cannot, however, look after numerous small plantation schemes scattered all over the territory with up to 40 or more annual planting areas in each scheme. Departmental timber plantations must be concentrated in comparatively few but relatively large areas. For economic purposes the annual coupe, or area to be cut, should be large enough to keep a sawmill going for the whole year. This may mean that the nearest departmental timber plantation is a long way off, probably in another district. There is no reason, however, why Native Authorities, when establishing a series of fuel and pole plantations, should not also plant some trees which can be left to grow to timber size. These may be of the same or of different species from those planted for fuel and poles. In a plantation purely for timber about 95 per cent of the trees will have been removed in several thinnings before the few remaining ones are large enough to fell for timber. Intermediate thinnings from timber plantations are often difficult to dispose of; they are too large, except for the top pieces, for building, are difficult to split up for fuel, and are too small to saw up for timber; they have only limited uses, such as bearers for bridges. The introduction of timber species should be at a wide spacing (30 ft. x 30 ft. or 24 ft. x 24 ft.) throughout the fuel and pole plantations. At the end of each rotation these trees will be left as "standards" over the coppice or seedling regrowth. This introduction of timber species at a wide spacing in fuel and pole plantations is not ideal forest management for the production of timber; it is, however, a useful compromise.

Disposal and Sale of Produce.—With privately-owned plantations the owner decides what should be done with the produce; the disposal of produce from communal plantations some years after their establishment is, however, not always easy, as many of the original workers may have left the area. This is really a political question and is beyond the scope of this article.

All produce, however, from Native Authority plantations should be paid for, even by the Native Authority itself. For the Native Treasury this is only a matter of double entry in the books, the royalty being charged against the work in question and credited under "Revenue from Forest Plantations", or some such heading. Produce used by the Provincial Administration or other Departments should be paid for; so should all produce taken by individuals. This payment makes the native appreciate the value of what he is getting and is likely to encourage him to raise his own little plantations. It also shows what return the Native Treasury is getting against the cost entailed in establishing its plantations.

GENERAL OUTLINE

The principal aim of forest management is to obtain approximately equal yields annually. To achieve this a series of plantations should be established so as to have approximately equal areas for cutting each year. Assuming the soil to be reasonably uniform the yield each year will be about the same. If this is so the plantations are said to give a "sustained yield".

A	B	C
D	E	F
G	H	I

FIGURE I

Figure I is a plan of an ideal Native Authority fuel and pole plantation worked on the basis of a sustained yield under a rotation of nine years. Each square represents the annual planting area; after the ninth year it becomes the annual coupe or cutting area.

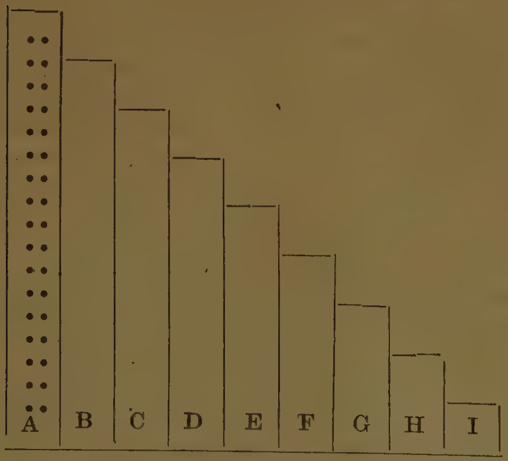

Figure II

Column A represents the coupes felled in the tenth and thirteenth years respectively.

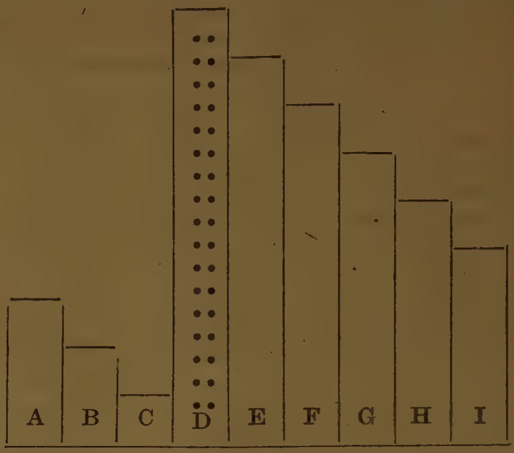

Figure III

Column D represents the coupes felled in the tenth and thirteenth years respectively.

Both Figures II and III are diagrammatic representations of the plantations; the rectangles represent the relative heights of the trees in the annual planting or felling coupes. The series may be referred to as "age gradations".

Figure II shows the position early in the tenth year after the felling of the first coupe; this coupe is "A", the first area to have been planted, nine years previously.

Figure III shows the position in the thirteenth year *after* the felling of the fourth coupe, "D", the fourth area to have been planted, again nine years previously.

To achieve a sustained annual yield it is necessary first of all to plant a given acreage each year; the planting being done as early as possible in the season. The acreage should be the same each year, assuming that the soil is reasonably uniform. The mere planting of a new area each year is not by itself sufficient however; areas planted previously still require attention for a few years. Weeding is necessary and, even more important, failures must be replaced; this is referred to as "beating-up". Both weeding and beating-up are neglected far too often. Trees, once planted, should not be left to look after themselves. After some years, say five to seven, thinning may be necessary before the trees in the plantation are large enough for clear-felling.

To get the fuel and poles required the annual planting area or coupe should be clear-felled at the end of the rotation, nine years in the above case. Most species, such as gums and *Cassia* (Ironwood) regenerate themselves by sending up new shoots, called "coppice". Wattle can be regenerated by encouraging seedling regrowth. To obtain larger sized poles for bridges, etc., a certain number of trees called "standards" may be left standing till the end of the second or third rotation. The question of leaving some trees or standards to produce timber has been considered above. These standards will usually be of a different species, if for timber.

A sample programme therefore for a single coupe, say "A", over a period of years might be:—

Year	*Operation*
1	Plant or sow and weed.
2	Beat-up and weed.
3	Beat-up and weed.
4	Weed.
5	Weed (if necessary).
6	———————
7	Thin (if necessary).
8	———————
9	———————
10	Clear-fell and regenerate.
11	———————
12	Thin coppice or seedling regeneration*.
13–15	———————
16	Thin (if necessary).
17–18	———————
19	Clear-fell and regenerate.

Thus, to get a sustained yield from the whole of the area all the operations shown in Table I should be carried out in the years indicated for each annual area planted.

P	Planting (or sowing).
W	Weeding.
w	Weeding (if necessary).
B	Beating-up.
T	Thinning.
C	Cutting or clear-felling.
Tr	Thinning regeneration.

All this, of course, is for an ideal series of plantations. The necessity for operations such as beating-up and weeding will depend considerably on the success of the first year's planting or sowing. So too will thinning; the necessity for thinning and the year for it will also depend on the rotation and on the spacing. The rotation may be longer or shorter than nine years according to the rate of growth of the species selected. The year for thinning the coppice or seedling regeneration will depend on how quickly it grows and its density; in the case of wattle it is probably best for the first thinning to be done by pulling up the seedlings in the rains when the plants are about 1 to 2 ft. high to give a spacing of about 1 ft., then to thin out to 4 ft. when 5 to 6 ft. high and finally to 8 ft. (or up to 11 ft. if for bark production) when about 20 ft. high.

TABLE I

PLANTING AREA OR FELLING COUPES

YEAR	A	B	C	D	E	F	G	H	I
1 ..	PW								
2 ..	BW	PW							
3 ..	BW	BW	PW						
4 ..	w	BW	BW	PW					
5 ..	w	w	BW	BW	PW				
6 ..	—	w	w	BW	BW	PW			
7 ..	T	—	w	w	BW	BW	PW		
8 ..	—	T	—	w	w	BW	BW	PW	
9 ..	—	—	T	—	w	w	BW	BW	PW
10 ..	C	—	—	T	—	w	w	BW	BW
11 ..	—	C	—	—	T	—	w	w	BW
12 ..	Tr	—	C	—	—	T	—	w	w
13 ..	—	Tr	—	C	—	—	T	—	w
14 ..	—	—	Tr	—	C	—	—	T	—
15 ..	—	—	—	Tr	—	C	—	—	T
16 ..	T	—	—	—	Tr	—	C	—	—
17 ..	—	T	—	—	—	Tr	—	C	—
18 ..	—	—	T	—	—	—	Tr	—	C
19 ..	C	—	—	T	—	—	—	Tr	—

and continued on same system.

WORKING PLAN

Let us assume now that the Native Authority is to establish a fuel and pole plantation near the Chief's Headquarters. In preparing the plan certain principles must be considered; these are:—

(i) Total area.
(ii) Demarcation.
(iii) Species.
(iv) Timber.
(v) Preparation of Land.
(vi) Planting distance.
(vii) After-care (or maintenance).
(viii) Finance.

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* May not be necessary till thirteenth year; it should be done only when the young trees are large enough to be disposed of as withies ("fito").

Total Area.—The total area required to give a sustained annual yield should be estimated and *all the ground* selected in advance. The acreage of the annual planting area—"A", "B", "C", etc., will depend on the funds and labour available, the probable future requirements of the locality, and on the land which is not required for agriculture or grazing. The rotation in years will depend mainly on three things: the species; the size of material required; and, the growth factors of the locality; for poles it will be from five to ten or twelve years according to altitude, rainfall and soil. If "x" is the acreage of the annual planting area and "y" the rotation, then the total area will be "xy" acres.

It might not be possible to have all the annual coupes in one compact block; coupes A to E may be in one place and coupes F to I a mile or so away, say across a valley. Scattered blocks, however, mean considerably longer boundaries to protect from fire, and perhaps from stock, and they make supervision more difficult. Unfortunately, this separation may often be necessary to get the required total area.

The local Forest Officer should always be consulted before a definite decision is made about the total area, and also, of course, about the species. The area or areas should be as close as possible to roads to save travelling time when inspecting the work.

Demarcation.—To ensure continuity, and to enable all future officers and also the local natives to know what is envisaged, the total area should be demarcated permanently on the ground at the start. This is probably best done by planting, say sisal, or by the trenching of each alternative five yards of the boundary; a continuous trench may lead to gulley erosion. The soil should be thrown out into the required area. An imaginary line between two beacons is of little help to most Africans.

Species.—The two chief considerations here are (*a*) ease of establishment, and (*b*) ease of regeneration. Species such as Ironwood (*Cassia siamea*), or Wattle which can be sown direct are to be favoured if one or the other will grow; this direct sowing avoids expensive nursery work. Indigenous species such as the *Acacias* might prove useful also. For ease of regeneration species which coppice readily, such as Ironwood, or gums, are to be preferred, though natural regeneration of wattle is fairly easy. Gums, however, must be raised in nurseries; this requires a better trained staff and more supervision, as well as increased initial costs. This extra cost, of about Sh. 25 per acre, may be offset in the long run by the ease of getting coppice regeneration and by the greater yield from the coppice in subsequent rotations. The local Forest Officer should be consulted before deciding finally on the species to be planted.

Timber.—The selection of species for timber must be made with care, should it be decided to plant any. Here again the advice of the local Forest Officer should be sought. At a spacing of 30 ft. x 30 ft. only 48 plants per acre would be required for interplanting. Timber species could, if necessary, be nursery raised at but a small cost, even if the fuel and pole species are being sown direct. Silky Oak (*Grevillea robusta*) is quite a useful timber species which also improves the soil with its leaf litter, though it cannot, of course, be grown everywhere. Lucky Bean or "Mkola"—*Afzelia quanzensis*—can be sown direct in such areas as Sukumaland. Blackwood Acacia (*Acacia melanoxylon*) is fairly fast growing and yields a good timber. There are many others with varying requirements of soil and climate.

Preparation of Land.—This should be thorough; too often it is skimped resulting in poor initial growth, many failures and expensive tending operations. For such information *see* Appendix II of Grant [1].

In all areas of comparatively low rainfall, e.g. Sukumaland, ridging and tie-ridging is strongly recommended by Prentice [3]. Important points to notice are:—

(i) Build up the ridges on previously cultivated strips.

(ii) Build up the ridges along the contour as far as possible.

(iii) Have the tie-ridges or cross ridges close together—three to six yards according to slope—so as to hold up the water.

(iv) Do not try to dam definite storm-water courses; leave a gap.

(v) When weeding, return the weeds and soil to the ridges; the tendency is always to break the ridges down and thus expose the roots.

(vi) Repair any washaways as quickly as possible.

Details of this method for tree planting are given by Pitt [2].

As labour is in short supply at the beginning of the rains it is advisable to do most of the ground preparation well ahead; where the ground is hard (e.g. Sukumaland) this work can be done at the end of the previous rains; labour then is usually plentiful, it being before the main harvest. If the land is prepared well ahead, only a small labour force for the actual sowing or planting will be required when the rains commence. Also, the trees will get a better start, and failures can be beaten up in the first season some months before the end of the rains. Because labour is not available early in the rains the sowing or planting is, only too often, done near the end of the rains, with the result that many plants are not established well enough to survive the ensuing dry season. If possible African cultivators or "squatters" should be encouraged to cultivate in the area a year or so ahead of the planting. After a few years, when the trees become established, the squatters move on ahead to a new planting area.

Planting Distance.—This is always a compromise. The wider the spacing the fewer the plants required, e.g. 6 ft. x 6 ft. requires 1,210 plants an acre, 8 ft. x 8 ft. only 680 plants an acre. On the other hand, the wider the spacing the longer the leaf canopy takes to close up and the more weedings are necessary. A closer spacing may necessitate an intermediate thinning a few years before the end of the rotation; this is advantageous if the produce can be disposed of, but thinning is not too easy an operation. For simplicity, the spacing and rotation should generally be such as to avoid the need of a thinning.

After-care or Maintenance.—This is frequently overlooked, both in estimating costs and in deciding what work should be done. In the first, and subsequent years, plantations must be kept weeded to reduce competition and fire danger. "Squatters" help in this respect. When weeding round young plants or seedlings, all weeds with their roots should be pulled out by hand and the soil shaken off and left; the weeds should then be laid down as a mulch round the plants. If the soil is hard it can be loosened first with a sharp pointed stick. A thick mulch should be laid down round the plants before the first dry season sets in, or earlier; this mulch prevents the soil drying out too quickly and will help to keep down weeds the next season. When the trees get up to 4 to 6 ft. it may be better to cultivate the whole area and dig in the weeds; the weeds and the good top soil should not just be scraped away from the young plants. The mulch, if required, can be renewed round the plants after this cultivation. It may, however, act as a good start for a fire in the dry season if fire protection measures are not taken.

Failures must always be replanted; the quicker complete stocking is obtained the sooner the canopy closes and the sooner weeding becomes unnecessary. New plantations should not be started if much work is necessary on areas planted in previous years, especially if time, labour or funds are limited. In other words—one must consolidate before attempting new gains.

The thinning of plantations is a most important operation, but it is all too often neglected. Briefly, all dead and dying trees should be cut out and also those which have been suppressed or are diseased; some of the more vigorous and healthy trees should also be removed so as to leave more room for the remainder, care being taken not to leave large gaps in the plantations. Details are beyond the scope of this article but the advice of the local Forest Officer should be sought.

Finance.—As will be seen from Table I, operations increase annually up to a point, become constant and then gradually fall off. To ensure continuity, therefore, funds should be available to cover a period of years, not just from year to year. To appreciate what is required let us substitute figures for letters for the operations given in Table I. These figures must be regarded as very approximate as so much depends on the success of the previous season's planting; the figures below are based on fifty cents (6d) a man-day, the plantation being established by direct sowing. About an extra Sh. 25 per acre should be spread over the first three years should nursery plants be used.

Taking the operations given in Table I for coupe A we get the following:—

Year	Operation		Approximate cost per acre
	1st Rotation		*Sh.*
1	Plant or sow and weed	PW	40
2	Beat up and weed	BW	25
3	Beat up and weed	BW	15
4	Weed	w	10
5	Weed (if necessary)	w	10
7	Thin (if necessary)	T	10
	2nd Rotation		*Sh.*
10	Clear-fell and regenerate ..	C	20
12	Thin regeneration (when of withy size)	Tr	20
16	Thin (if necessary)	T	10

These operations may sometimes be carried out by the people taking the produce; for better control, however, it may be advisable to use paid labour.

TABLE II

COST OF PLANTING AND MAINTAINING ONE ACRE A YEAR IN SHILLINGS

YEAR	A	B	C	D	E	F	G	H	I	ANNUAL TOTAL	RUNNING TOTAL
1	40									40	
2	25	40								65	105
3	15	25	40							80	185
4	10	15	25	40						90	275
5	10	10	15	25	40					100	375
6	—	10	10	15	25	40				100	475
7	10	—	10	10	15	25	40			110	585
8	—	10	—	10	10	15	25	40		110	695
9	—	—	10	—	10	10	15	25	40	110	805
TOTAL	110	110	110	100	100	90	80	65	40	805	
10	20	—	—	10	—	10	10	15	25	90	895
11	—	20	—	—	10	—	10	10	15	65	960
12	20	—	20	—	—	10	—	10	10	70	1,030
13	—	20	—	20	—	—	10	—	10	60	1,090
14	—	—	20	—	20	—	—	10	—	50	1,140
15	—	—	—	20	—	20	—	—	10	50	1,190
16	10	—	—	—	20	—	20	—	—	50	1,240
17	—	10	—	—	—	20	—	20	—	50	1,290
18	—	—	10	—	—	—	20	—	20	50	1,340
TOTAL	50	50	50	50	50	60	70	65	90	535	
TOTAL FOR TWO ROTATIONS	160	160	160	150	150	150	150	130	130	1,340	

In round figures, it costs about Sh. 100 an acre to establish a plantation for fuel and building poles; in the second rotation it may cost a further Sh. 50 if paid labour is used for the various operations; these figures should be more than covered by revenue from the sale of the produce. Up to Sh. 200 an acre (1,000 poles at 20 cents) can be collected from the sale of fuel and poles felled in the plantation at the end of a rotation.

It should be noted that expenses increase up to the fifth year by about 2½ times the initial expenditure. After this it remains fairly constant to the end of the rotation. If £100 is available, therefore, at the start, about £250 must be available by the fifth year. In the second rotation the figure will drop to about £120, or much less if the purchaser does the cutting. Any expenditure should be covered, of course, by this time by revenue.

Failure to appreciate this increase in cost over the first few years has often curtailed subsequent operations; frequently it has meant that maintenance has been neglected in favour of work on new areas, hence bad plantations with gaps, much grass competition and frequent damage from fires.

In drawing up estimates, therefore, the figure given in the annual total column must be multiplied by "x", the acreage of the annual plant. This should be increased by about 25 per cent to allow for overheads on headmen, fire protection and for contingencies. A further amount of about Sh. 25 per acre spread over about three years should be added if nursery raised plants are to be used instead of direct sowing; the figures per acre for the first three years would then be about Sh. 55, Sh. 30 and Sh. 20 instead of Sh. 40, Sh. 25 and Sh. 15.

With labour at 50 cents a day all the figures given above should be more or less maxima. With work carefully supervised costs should be rather lower.

ADAPTATION OF EXISTING PLANTATIONS

Owing to lack of planning in the past, or to lack of continuity, there are many plantations without a regular set of age gradations. Future work, therefore, must be planned so as to bring things into line; this will necessitate felling some of the plantations earlier or later than the end of the prescribed rotation. This planning should be done in conjunction with the local Forest Officer.

An example of an actual plan of this nature is given in Table III. The plantations up to 1944 had been unplanned, as can be seen from the different sized plantations. They have now been numbered and grouped into three approximately equal-sized compartments. Also, the remainder of the total area (compartments 4, 5 and 6) required to give a sustained yield has been selected, demarcated (by ploughing a double furrow) and divided up into three more equal-sized compartments or coupes. As these are the first plantations in this area it is not known exactly how fast the trees will grow; the plan is, therefore, elastic. It should be noted that it is the number of coupes which can be altered, not their size; also, that beating-up is to be carried out before any new planting begins. Expenditure has not been referred to as there are other plantations in adjoining areas and labour is switched from one to the other as required. Native Authority headmen cannot usually be expected to keep an accurate analysis of how the labour is employed. It is the total cost for all the planting activities in the district which concerns the Native Treasury.

SPECIAL PLANTATIONS

Areas planted as shelter-belts or for anti-erosion purposes can often be felled and regenerated, usually in strips, to assist in the production of a regular or sustained yield.

TABLE III

NYABASI WORKING PLAN, NORTH MARA DISTRICT, TANGANYIKA
GUM COPPICE WITH GREVILLEA STANDARDS

(5) Gums 1946 3 acs. *1952*	(3*b*) E. Cit. 1944 (Apr.) 1 ac. *1950*	(2*c*) Grev. 1942 (Oct.) ¾ ac. *1949*	(2*b*) E. Cit. 1942 (Oct.) 1½ acs. *1949*	(1*a*) E. Cit. 1942 (Apr.) 2½ acs. *1948*	(1*b*) E. Cit. 1943 (Apr.) 1¼ acs. *1948*
←TARIME			ROAD		BWIREGI→
(6) Gums 1947 3 acs. *1953*	(4) Gums 1945 3 acs. *1951*	(3*a*) E. Cit. 1944 (Apr.) 2 acs. *1950*	WATTLE 1941 (Apr.) 4½ acs.	WATTLE 1942 (Apr.) 1 ac.	(2a) E. Cit. 1943 (Oct.) 1¼ ac. *1949*

Legend:—(2c) Number of compartment (felling coupe or planting area).
1944 Year of planting.
1949 Year for felling.

N.B.—All compartments having the same number must be felled in one year.

Rotation (provisional)—6 years.

Annual Coupe—Three acres (approx.).

NOTES

(1) The beating-up of compartments 1a, 1b, 2a, 2b, 2c, 3a and 3b must be completed before compartment 4 is planted.

(2) Maize may be interplanted in the first and second years.

(3) A thick mulch of grass, 3 ft. wide and 6 in. thick should be placed round the young plants at the first weeding; this weeding must be done before the plants are smothered.

(4) *Grevillea* (for timber) has been introduced into all the *Eucalyptus citriodora* and other gum plantations at about 24 ft. by 24 ft. (every fourth plant in every fourth row). In the new compartments, viz. 4, 5 and 6, *Grevillea* should be planted at this spacing before the gums are put in.

(5) In 1948 if compartments 1a and 1b are not ready for felling (trees too small) they should be left for a year and a new area—compartment 7—of three acres planted up, thus increasing the rotation to seven years. Should, however, the trees be large enough for felling in 1947, they should be felled then and and compartment 6 left unplanted, thus reducing the rotation to five years.

(6) In any one year do not plant or fell more than the prescribed area.

(7) *Grevillea* must not be felled until it is of timber size.

(8) The beating-up of the wattle should be done early in 1945. Later it must be felled and regenerated independently of this plan.

INCREASING PRODUCTION

We have so far dealt with but one single series of plantations in any one area. By the end of the rotation it may be found that the produce from "x" acres a year is not sufficient to supply all demands. A second series should, therefore, be started; the area of "x", the annual plant, need not be the same as before, nor need "y", the rotation, be the same.

AVENUE PLANTING

Although the planting of an avenue has nothing to do with fuel and pole plantations, it is an operation which both Administrative Officers and Native Authorities frequently have to carry out. The trees should be widely spaced from the start at 30 to 36 ft. and they should be at least 15 ft. back from the edges of the road. Do not put in the trees close together, saying that Nature will reduce them; she will, but not regularly. Plant at the final spacing and replant failures. With the wide spacing of 10 to 12 yards not many trees will be required to a mile of road, and the replacing of failures and weedings will not be expensive. By having the trees well back from the edge of the road, and widely spaced, the road surface will be able to dry out more quickly after rain.

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KAVIRONDO PERENNIAL SORGHUM

AN IMPROVED TYPE, R2S42

By D. C. Edwards, Senior Agricultural Officer, Pasture Research, Kenya

(*Received for publication on 26th February, 1948*)

In this Journal, Vol. VI, pp. 183–186, April, 1941, the possibilities of a new fodder crop, Kavirondo Perennial Sorghum, were described and preliminary work on the crop was reported.

The material under experiment at that time was derived from a plant found in 1935 near Maseno in the Kavirondo area of Kenya. This plant appeared to have resulted from natural crossing between a cultivated grain sorghum and *Sorghum verticilliflorum* Stapf, a widely distributed indigenous plant.

The unimproved material, in which several clearly different types appear spontaneously, has gained a certain degree of popularity for silage production and aftermath grazing in the drier agricultural regions of both Kenya and Tanganyika over the past six years. Work on the selection of these types was foreshadowed in the above-mentioned article, and the purpose of the present note is to report progress in breeding and selection towards improvement of the crop.

Four distinct varieties of the sorghum have been obtained by open selection. These have been called the "Black", "Red", "White" and "Mtama-like" types. In addition, attempts have been made to "self" selected plants from each type. As a result of this latter work, a line which appears to be distinctly superior to the original material has emerged. This is known as "R2S42", which indicates that it is derived from the second red plant self-pollinated in 1942.

Considerable increase of the material obtained from this plant has been accomplished, and sowings made on several acres of land show good uniformity of type, although there is probably scope for further selection. The chief points in which R2S42 surpasses the original material are that it is distinctly more robust and leafy and it gives a heavier crop, in which the plants attain 9 or 10 feet in height. The inflorescence combines the semi-naked fruits characteristic of the "Mtama-like" type with the open panicle of the other three types. The appearance of the fruits suggests that the crop might serve the dual purpose of both fodder and grain production.

It is now proposed to replace the limited commercial seed supply of the original Kavirondo Perennial Sorghum by the superior R2S42, using the name "Improved Kavirondo Sorghum" to distinguish the new type.

TEMPORARY LEY GRASS TRIALS ON THE UASIN GISHU PLATEAU, KENYA COLONY

By W. A. C. Bouwer, Eldoret, and L. R. N. Strange, Assistant Agricultural Officer, Kenya

(*Received for publication on* 16*th February*, 1948)

Owing to the necessity for the highest possible production of cereals during and after World War II, the total acreage under wheat in the Uasin Gishu District of Kenya has risen from 45,816 acres in 1941 to 87,679 in 1947. Most of this land is being farmed on a system of non-stop cropping with cereals. To-day one may find instances where fields have carried cereals for 25–30 years, while a succession of cash crops for 10–15 years on the same land is regarded as normal practice. At the same time many landowners have burned crop residues each year, a dressing of 100–200 lb. phosphates, drilled with the crop, being the only concession to the theories of good farming. The result, as might be expected, has been deterioration of soil structure and an alarming increase in erosion, even on farms where the arable land is comparatively flat. At the start of the drive for full crop production, it was realized that much land would suffer and that sooner or later there would have to be a big effort to change to a more conservative system of farming. This would involve greater emphasis on live stock, and the planting of old wheat lands with suitable temporary ley grasses. Before definite advice could be given to farmers, however, it was necessary to carry out trials with different grasses, to try and find the best methods of planting and the best types to plant. Accordingly, in 1943, the first experimental plots were laid down on land where conditions are fairly typical of the main wheat-producing areas, and where the owner was keen to co-operate. The altitude of the farm is about 7,100 feet, having an average annual rainfall of just over 40 inches. The soil is a reddish-brown loam, typical of the plateau.

LAYOUT AND DETAILS OF TRIALS

In May, 1943, three strips of grass were seeded down in pure stand. The seed beds for these were prepared as for planting wheat, and each plot was about one acre. The following grasses were used:—

Molasses Grass (*Melinis minutiflora*)—seed rate, 10 lb. per acre.

Nzoia Rhodes Grass (*Chloris gayana*)—seed rate, 15 lb. per acre.

Mountain Brome (*Bromus marginatus*)—seed rate, 25 lb. per acre.

Objects.—(*a*) To find out whether or not any of these would make satisfactory growth under prevailing conditions;

(*b*) to provide plots for seed, grazing and observation.

Results.—There was a good germination in each case. The Mountain Brome (*Bromus marginatus*) died out during the dry season of 1943/44, thereby showing itself unsuited to the area. The other two species made excellent growth and are still thick and flourishing at the time of writing, nearly five years after sowing. Sowing was done with a special grass seed barrow, the seed being covered subsequently by walking weeder.

In June, 1944, a small area of wheat was planted and about two weeks later, after the wheat had germinated, seed of Rhodes and Molasses Grass was planted in the crop in two separate strips. The same grass seed barrow was used for sowing. Seed rates were as before. Lucerne (Hunter's River) was broadcast in mixture with each of the grasses at the rate of two pounds per acre.

Objects.—(*a*) To find whether these two grasses could be established under a wheat nurse crop;

(*b*) whether the resulting pastures would compare favourably in vigour with those sown down in pure stand during the previous season;

(*c*) whether lucerne would be a suitable leguminous plant for including in temporary ley mixture.

Results.—A good stand of young grass seedlings grew up with the wheat and carried through the dry season of 1944/45, making an excellent pasture soon after the start of the rains in 1945. The grass had no apparent ill effect on the growth of the wheat, a normal crop being harvested in November of that year. The wheat slightly retarded growth of grass seedlings, but this was expected and proved to be temporary. Both these strips are still in excellent condition at the time of writing, and are in no way inferior to the plots established in pure stand during 1943. The lucerne made fair growth in competition with the grass in 1945, but died out almost completely during 1946.

In June, 1945, two blocks, each divided into six one-fifth-acre plots, were drilled with Sabanero Wheat at varying seeding rates. Molasses Grass was sown on one block of six plots at the rate of 6 lb. per acre, while the other block was sown with Rhodes Grass at 10 lb. per acre. Lucerne was used also in the mixture. The seeding rates used for the wheat were as follows: 75 lb. per acre; 60 lb. per acre, and 45 lb. per acre, varying in each one-fifth-acre plot, each treatment being repeated twice on both blocks. Phosphatic fertilizers were drilled in with the wheat as normal. Grass seed was sown with the barrow as before, but was put in on the same day immediately after the wheat had been drilled. After all sowing was finished, Uganda Rock Phosphate and pure triple superphosphates were drilled in two lines across all the strips at the rates of 600 lb. and 100 lb. per acre respectively.

At the same time a small strip was sown in pure stand with an equal mixture of Rhodes and Molasses Grass.

Objects.—(*a*) To observe the effects of light and heavy stands of wheat on the growth of under-sown grass seedlings;

(*b*) to note the effect of phosphatic fertilizers on growth of grass;

(*c*) to confirm that a satisfactory temporary ley can be established in a wheat nurse crop under prevailing conditions;

(*d*) to try the two grasses in mixture.

Results.—The result was that there was no visible difference in the growth of grass seedlings under thinly sown wheat (at 45 lb. per acre) as compared with the other seeding rates (60 lb. and 75 lb. per acre). Further, the grass seed can be sown on the same day as the wheat without ill effect on either crop. This trial also showed that seeding rates of 6 lb. for Molasses and 10 lb. for Rhodes are too light, and that to obtain a satisfactory stand in the first season it is advisable to sow at least 10 lb. per acre for Molasses and 15 lb. per acre for Rhodes. The pastures resulting from the lighter sowings took a season longer to thicken up and cover the ground than where a heavier seeding rate was used. Weed growth was strong, and two or three mowings were necessary. As before, the lucerne germinated well but disappeared the following season.

It was interesting to note also that the yields of wheat differed very little as a result of reduced seeding rates. Yields were as follows:—

75 lb. per acre seeding gave an average of 1,635 lb. of wheat per acre.

60 lb. per acre seeding gave an average of 1,625 lb. wheat per acre.

45 lb. per acre seeding gave an average of 1,470 lb. wheat per acre.

Uganda Rock Phosphate and triple superphosphate both had a marked effect on the growth of the grass, the lines showing up clearly across the field. It was noticed later that when the pasture was first grazed, cattle tended to concentrate on the two lines where fertilizers had been applied in preference to the rest of the pasture. The small strip where grasses were sown in mixture came away well, the two types holding a good balance up to the present date.

In May, 1946, four strips, two of Molasses Grass and two of Nzoia Rhodes, were sown in pure stand on blocks of two acres each. In June four adjoining strips of the same size were sown under a wheat nurse crop (using Regent wheat). A normal seeding rate of 70 to 75 lb. per acre was used for the wheat. Grass seed rates were 10 lb. for Molasses and 15 lb. for Rhodes. The grass was sown immediately after the wheat had been drilled, and was covered by rolling in. After all strips had been sown in June, Uganda Rock Phosphate at 372 lb. per acre and silicophosphate at 168 lb. per acre was drilled in in two separate lines across the whole experimental area.

In May of the same year a small plot of Red Oat Grass (*Themeda triandra*) was sown in pure stand.

Objects.—(*a*) To obtain final confirmation that under these conditions, temporary leys can be established as satisfactorily under wheat as in pure stand;

(*b*) to observe once more the effects of phosphates on the growth of grass;

(*c*) to find whether Red Oat Grass might be suitable for use in temporary ley seed mixtures.

Results.—At the start of the rains in March, 1947, grass which had been planted under wheat was actually looking better than that sown in pure stand. The reasons for this were:—

(i) Weed growth was stronger in the pure stand plots and tended to suppress the grass.

(ii) The wheat stubble and loose straw after harvest gave some protection from the sun to grass seedlings during the dry months of December, January and February.

(iii) Fertilizer which had been drilled in with the wheat stimulated growth of grass.

Later on, however, during the rainy season of 1947, it was noticeable that the strips which had been sown in pure stand grew more quickly than those sown under wheat. The reason for this was that wheat straw which was left to rot on the surface of the ground caused some denitrification and yellowing of the young grass. By the end of the rains in 1947, the strips sown in pure stand were still noticeably greener and more vigorous for this reason. It is believed that the difficulty of nitrogen deficiency caused by decomposing of straw could easily be overcome through dressing with sulphate of ammonia, or by the use of a movable fence to ensure heavy concentration of dung and urine on the young grass.

Once more the strips drilled with extra fertilizer showed up clearly, particularly where silicophosphate was used.

Red Oat Grass gave poor germination and grew slowly, showing itself unsuitable for temporary leys in this area.

CONCLUSIONS

The following are some conclusions which may now be drawn from this work. It must be remembered that these results will not necessarily apply to other areas where conditions are different:—

Both Nzoia Rhodes Grass and Molasses Grass are suitable for temporary leys and will give excellent grazing for at least four years providing the soil is of average fertility.

Mountain Brome fails owing to its inability to withstand the dry season.

The sowing of temporary leys under wheat gives as good results as sowing in pure stand. The exception to this is where decomposing wheat straw causes denitrification, with yellowing of the grass. This, however, is not considered a very great drawback and may be overcome as suggested.

The sowing of a grass ley under a cereal nurse crop is more satisfactory because—

(*a*) the pasture is established a season sooner than would otherwise have been possible, and without losing a crop;

(*b*) the same work and cultivation serves for both crop and grass, thereby reducing costs of establishing the pasture.

A normal seeding rate of 70–75 lb. per acre for wheat can be used. Lighter seeding rates make no noticeable difference to the growth of grass.

Seed of both grasses may be sown by broadcasting by hand or with a grass seed barrow. Sowing through the fertilizer attachment of a wheat drill is now being tried in another experiment, and results so far indicate this method to be very satisfactory.

A covering by brush harrow, walking weeder, light drag harrow or rib roller is advisable. The seed should not be covered too deeply.

Given seed of average viability, rates for seeding should not be less than 10 lb. per acre for Molasses, and 15 lb. per acre for Rhodes Grass.

Dressings of phosphatic fertilizers when applied with the seed, show a beneficial effect on the growth of the grasses.

Seed may be harvested mechanically by cutting with reaper and binder, drying in the field, then threshing by hand, or by a combine harvester fitted with the necessary screens and cleaning device.

N.B.—When a combine is being used, the blower should be disconnected or closed as much as possible.

Molasses and Rhodes have a high carrying capacity (probably at least double that of the local natural pastures), and are both readily eaten once the cattle have become accustomed to them. During the dry season they both remain green for a long period and will withstand heavy grazing.

The two types will hold a satisfactory balance of growth for at least four seasons when sown in an even mixture.

Lucerne dies out after the second season when planted in mixture.

Red Oat Grass is not satisfactory for temporary leys as seed is difficult to harvest and is of low viability.

Where soil fertility has fallen low as a result of erosion and excessive cropping, it may be advisable to sow temporary leys in pure stand rather than under a cereal. The reason is that excessive competition between grass and cereal may cause the failure of one or both. The obvious thing to do, however, is to dress such land with six to ten tons per acre of cattle manure or compost before trying to establish the pasture.

Note by Senior Agricultural Officer, Pasture Research, Kenya

The work described in this article is a good example of the link which co-operative experiments can provide between the results of research and the application of these results to farming practice. In 1943 when the experiments described by Messrs. Bouwer and Strange were initiated, the position was as follows:—The three ley grasses, Nzoia strain of Rhodes Grass (*Chloris gayana*), Mountain Brome (*Bromus marginatus*) and Molasses Grass (*Melinis minutiflora*), were available, but since, vegetationally, the greater part of the Uasin Gishu Plateau is transitional between two main types associated with different climatic regions, it was obvious that trials would be necessary in order to show which of the above grasses would be the most successful. Further, no experimental evidence as to the possibility of establishing the grasses under wheat then existed although sowing under maize had previously proved practicable. The Nzoia type of Rhodes Grass is a result of investigation over a considerable number of years aimed at the discovery of indigenous grasses having good persistence under grazing and good seed-producing qualities. This work was designed to meet the needs of ley farming in the most extensive agricultural region of the country. Some results of the work were described in this Journal, Vol. IX, pp. 62–68, October, 1943, "The Nzoia Type of Rhodes Grass (*Chloris gayana*) for Temporary Leys".

The present article gives evidence which appears to indicate clearly that both Nzoia Rhodes Grass and Molasses Grass fully meet the requirements of the area under discussion, while Mountain Brome Grass can be ruled out. In this connexion, however, it is important to observe that in most other areas under the climatic conditions given, i.e. 7,000 feet elevation and 40 inches of rain per annum, this last-named grass would succeed. The results serve to indicate once more that altitude and rainfall figures alone are insufficient to represent climate and that the natural communities of vegetation afford a much more reliable guide. In the case of the Uasin Gishu Plateau, as already noted, the vegetation is transitional between the type of the cool, high-moisture regions in which Mountain Brome Grass thrives and the warmer country at lower elevations where Nzoia Rhodes Grass can normally be used, despite the relatively high altitude and recorded annual rainfall of the Plateau.

In the region under consideration, phosphatic manuring is a necessary adjunct of cereal production, and the authors have presented evidence indicating that the pasture ley will also benefit from this treatment. In addition, the information given upon the relative seed rates of wheat and grass and upon the methods of sowing used is of great practical value.

D.C.E.

JACARANDA BLIGHT

People who are cutting down their Jacaranda trees because of the unpleasant blight which has recently over-run East Africa might do well to stay their hand for the time being.

The blight, *Orthezia insignis*, which causes a blackening disfigurement of the tree and all beneath it, is a coccid of mealy-bug type which has so far withstood all attempts at direct or biological control. Fresh hope, however, comes with a ladybird, *Hyperaspis jocosa* which, on the eighteenth of February, was introduced into Kenya from Hawaii by the Forest Department, Nairobi. The success or otherwise of this venture will be announced later by the Forest Entomologist.

TRYPANOSOMA SIMIAE (BRUCE) INFECTION OF THE CAMEL

By Dario Pellegrini, Merca Veterinary Research Institute, Somalia

(*Received for publication on 20th December, 1947*)

Di Domizio (1929) described a rapidly fatal trypanosomiasis in a camel, which he considered to be due to *T. simiæ*, though he expressed a doubt that it might have been an aberrant form of *T. congolense*. An examination of his drawings, photomicrograph and biometric tables justifies the conclusion that this was in fact *T. simiæ*. No other reference to *T. simiæ* infection in camels can be found in the literature.

The writer has encountered a number of cases of this trypanosomiasis in camels during the last few years, and it is considered that, after the pig, the camel is the most susceptible animal. Studies on the disease caused are recorded below.

NATURAL INFECTION

Hyperacute Form.—In this form, a camel which overnight was quite healthy may be found sick in the morning and may die during the course of the day. The animal shows signs of giddiness, staggers and shakes its head and neck with irregular movements. Salivation and lachrymation are intense. It stands with its forelegs apart and dies lying on the sternum or else on its side. Death may be preceded by convulsions.

Acute Form.—The acute form shows symptoms more typical of other trypanosomiases. The camel becomes listless and does not take its food. The mucous membranes are congested. Lachrymation is intense and the respiratory rate is increased. These symptoms become intensified; appetite is completely lost; the central nervous system is greatly depressed. The animal lies down and can only be induced to stand for a few moments at a time. Death occurs with symptoms of nervous involvement. The course is four to five days.

Chronic Form.—In this form, the acute crisis is overcome and a seeming recovery takes place. The animal starts again to graze, but its strength is not maintained. There follows a condition of slow but progressive exhaustion, accompanied by anæmia. Death occurs in one to two months with a marked degree of cachexia.

General Symptoms.—In no case was the temperature unduly high and this corresponds with the findings in experimental cases. The course in the hyperacute form resembles that of *T. simiæ* infection of the pig, and in the acute and chronic forms it resembles the disease caused by *T. brucei*, as described in an epizoetic in Somalia.

Incubation Period.—In one case, a camel (No. 5) died of hyperacute trypanosomiasis at least 20 days after it had been removed from a tsetse-infested area. Di Domizio (loc. cit.) recorded an incubation period of 35 days. In the experimental cases, one camel became infected in six days and the other in 17 days. Possibly, poor condition in the first animal contributed to the short incubation period; in the second case there may have been some loss of virulence in the trypanosomes due to delay in using them for infection purposes.

Pathology.—The lesions were similar to those of other acute trypanosomiases. Mucous membranes were congested; there were petechiæ and hæmorrhages of varying size, especially on the epicardium and endocardium. There was serous and sero-hæmorrhagic exudation into the thoracic, abdominal and pericardial cavities, especially the latter. The lymphatic glands were enlarged and hæmorrhagic, and the spleen was hypertrophied often to a very considerable extent.

In the chronic form, the state of nutrition is usually poor. The mucous membranes are pale; the heart muscle is flabby; gelatinous œdema is frequent in the subcutaneous tissues and among the muscles. The splenic enlargement is less marked and may be absent.

Treatment.—All forms of treatment were ineffective.

Distribution and Transmission.—Little is known, as yet, of the distribution of the disease. The cases described here became infected in the Genale area. It is, however, suspected that the disease extends along the banks of the Uebi Scebeli in the fly-infested area and in similar areas along the Juba River. Bruce and his co-workers (1912) implicated *Glossina morsitans*, but if, as is suspected, the disease occurs along the Uebi Scebeli, *Glossina pallidipes* must be implicated. In 1934 *Glossina austeni* too was found in the Genale area. Since *Glossina morsitans* is not found in Somalia it follows that both *G. pallidipes* and *G. austeni* must be suspected as the vector.

EXPERIMENTAL INFECTION

Two camels were experimentally infected by needle transmission from infected blood. The case histories are given below:—

Camel 1 (Adult Female).—Infected on 8-4-46 by injection subcutaneously of 20 cc. of infected camel blood. The parasites appeared in the blood stream 17 days later.

The disease was sub-acute, lasting 36 days. Symptoms were mild. There were moderate temperature rises (maximum 39.6° C.), and intense lachrymation during the first few days; after this the temperature gradually became normal. There was gradual emaciation and blood tests showed a progressive reduction of the number of red blood cells. Bennet's test gave a positive result. At death, cachexia was marked. Parasites were very numerous up to the twentieth day; they then decreased in number and disappeared from the twenty-sixth to thirty-second days. A few parasites were present in the blood during the last few days of life.

Camel 34 (Adult Male).—Infected by subcutaneous injection of 20 cc. of blood from Camel 1 at the acme stage. Incubation period was six days. The course of the disease was sixteen days. This camel was suffering from mange and in poor health and had been treated for a natural infection with *T. brucei* some months previously. There were slight rises of temperature and considerable lachrymation. No other marked symptoms were noted except for progressive weakness and cachexia, which culminated in death.

Phases of blood invasion by the parasite in very large numbers and phases of remission were noted, but the parasite was never entirely absent except on the twelfth day. On post mortem, the spleen was much enlarged and there was a great deal of pericardial fluid.

MORPHOLOGY OF THE TRYPANOSOME

Motility.—At the height of a heavy infection, the trypanosomes are very active, much more so than are *T. congolense*. The majority show continuous vibratory movements, but some show translatory movement, progressing in a wriggling fashion. During periods of remission and in light infections, movements are less active and resemble those of *T. congolense*.

Size.—Table I shows the length ranges of 400 trypanosomes, measured by Bruce's Camera Lucida method with an enlargement of 1,500 diameters.

General.—The body of the parasite is slim and very undulated. Individuals are also to be observed in which the anterior end is bent back into the body of the parasite. In most of the parasites the posterior extremity has a conical shape. The micro-nucleus is of a medium size, round, and usually it is placed laterally. The nucleus, placed in a central position, is of an ovoidal shape and occupies nearly the whole width of the protoplasmic body. The undulating membrane is clearly seen. However, parasites were observed in which this membrane was very narrow and little undulated. The flagellum may stop at the anterior extremity, but it may also continue for a short distance, or it may be absolutely free for as much as five microns of length, and this over and above the length of the parasite. In the hyperacute and acute forms, the numbers of parasites to be found in the blood are very large and may reach culture proportions. After the crisis, numbers are diminished and may even be absent from the circulation for short periods. At the height of infection, reproductive

TABLE I

LENGTH OF 400 *T. SIMIÆ* IN CAMEL (NATURAL INFECTION)

MICRONS		12	13	14	15	16	17	18	19	20	21	22	23	Minimum	Average	Maximum
Camel 5 ..	Number of Trypanosomes	2	8	10	16	15	28	14	4	2	—	—	1	12	16.15	23
Camel 2B ..		1	—	10	12	16	18	26	13	2	2	—	—	12	16.91	21
Camel 21 ..		—	—	7	16	18	21	20	12	6	—	—	—	14	16.91	20
Camel 35 ..		—	3	7	11	16	16	19	10	11	5	1	1	13	17.32	23
TOTALS ..	..	3	11	34	55	65	83	79	39	21	7	1	2	12	16.82	23
PERCENTAGES ..		075	275	855	1375	1625	2075	1975	975	529	175	029	090			

activity was very great, but the short forms were never seen in a state of division. Agglutination rosettes are frequent.

It will be noticed that, morphologically, the parasite has been described by us in its entirety; that is to say, we have not divided it into various types referring them to one or to another trypanosome of the congolense group, as has generally been done in the virulent infection of swine; briefly, we have considered it to be a well defined parasitical entity, as in fact it is.

It is not exceptional to find apart from the typical forms, short trypanosomes more or less similar to *T. congolense*, or long and thin forms with a narrow undulating membrane and a free flagellum (like those which have been described by Walravens under the name of *T. rodhaini*) and also thick elements with a swelling towards the posterior half of the body resembling *T. Montgomery*. It is this very peculiarity of polymorphism which is one of the characteristics of the parasite. The incidence of the various forms is not constant in all preparations and it varies in accordance with the subject, time and type of infection. In camels and sheep, but never in pigs, the short form sometimes predominated.

BIOLOGICAL TESTS

Monkeys.—Three monkeys (one *Cercopithecus* and two *Macacus*) failed to become infected by camel's blood.

Guinea-pigs.—Four guinea-pigs gave negative results.

Rabbits.—Of two rabbits, one showed a transitory infection lasting only one day. The other failed to become infected.

Squirrel.—One squirrel gave a negative result.

Dog.—One dog gave a negative result.

Sheep.—Five sheep were infected and all showed trypanosomes in the blood. Four of these recovered after suffering from a mild disease. The fifth sheep died, but was in such a bad state of health at the time of infection that its death cannot certainly be ascribed to trypanosomiasis.

Cattle.—Six cattle all gave a negative result. Absence of pathogenicity in the bovine is the crucial biological characteristic. Of all pathogenic trypanosomes found here, *T. simiæ* is the only one not even experimentally transmissible in bovines.

Pigs.—Two pigs became infected and died of acute trypanosomiasis.

DISCUSSION

The morphology and biological tests undertaken show definitely that the trypanosome studied was *T. simiæ*. Confirmation of Di Domizio's isolated report of a fatal trypanosomiasis due to this trypanosome in a camel is of interest, as also its tendency to cause an apoplectic form of the disease, similar to that caused in the pig. It is, however, to be noted that neither of the experimental camels developed the hyperacute form of the disease and virulence may be rapidly lost by needle transmission*.

SUMMARY

(1) Natural cases of *T. simiæ* infection of camels are described, associated with a disease of hyperacute, acute and chronic type.

(2) Two cases of experimental transmission of *T. simiæ* to camels are described.

(3) Infection with *T. simiæ* resulted in the deaths of all the camels studied.

(4) Morphological and biological data prove the trypanosome studied to have been *T. simiæ*.

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* In experiments in course on *T. simiæ* we have been able to reproduce in the camel through needle transmission a form of hyperacute trypanosomiasis similar to that observed in nature.

NOTES ON MVULE (CHLOROPHORA EXCELSA)

By James T. Templer, Forest Department, Kenya

(*Received for publication on 31st December, 1947*)

Mvule, or to use another common vernacular name, Iroko (*Chlorophora excelsa*) sometimes sold as African or Nigerian teak, but not to be confused with real teak (*Tectona grandis*), is a large deciduous tree, whose trunk sometimes has small buttresses to a height of about two feet. It attains a height up to 160 ft. with a straight cylindrical bole 50–80 ft. long and 20–30 ft. in circumference or up to 9 ft. in diameter, diameters of 3–5 ft. being commonest. The crown is large, composed of a few stout widely spreading branches; the bark is thick, ash-grey or brown to almost black, scaling in small reticulate patches towards the base of the trunk.

Its distribution is from Sierra Leone to Angola in West Africa, across to East Africa by way of Uganda, the Southern Sudan, Kenya Colony, Pemba Island, Tanganyika, Mafia Island, Nyasaland and Portuguese East Africa. Its altitudinal range is from sea level up to 4,500 ft. It is found scattered in both evergreen and mixed forests and in some parts of the coastal districts of Tanganyika and is a conspicuous feature of the landscape in sisal plantations and areas of native cultivation as also in Busoga, Uganda. Mvule occurs only in secondary forest, and can be taken as an indicator of sites previously occupied by African huts and of old termite mounds. In fact, there is much evidence in Uganda that the composition of the soil plays an important part in controlling the natural distribution of Mvule and evidence has shown that the tree is calciophilous in Uganda*.

The soil apparently preferred above all others is a deep, light, red loam, often called "red earth" by geologists. Over many parts of Africa this is formed in situ by the disintegration through weathering of the underlying rocks. These are often of the Basement Complex of Archean age, and the type that appears to make the best soil for Mvule is a granitic gneiss. In the Tanga Province of Tanganyika Territory it is best represented by the Mlingano and Muheza loams, and in the Coast Province of Kenya by the Arabuko–Sokoke ridge and extension northwards across the Sabaki River, and by the plains soils between Mackinnon Road and Tsavo railway stations. In Uganda large areas are underlain by the Basement Complex, some of which upon disintegration produces rather too heavy a soil for perfect Mvule conditions. This appears to be the case in some parts of the Buganda Province, Uganda.

This red soil by no means always carries a stand of Mvule nowadays, lack of soil moisture being the cause in some cases in areas of sufficient warmth, and insufficient warmth in others. In some cases also every single tree has been cut out and lack of sufficient soil moisture has prevented natural regeneration. This has probably happened in many parts of the Coast Province of Kenya, such as Mombasa, Gede, Malindi and Mambrui.

The lower limit of average rainfall for the soil type indicated above is probably about 30 in. per annum for Mvule growth. That is to say Mvule will, if artificially established, grow thereon, but with such a low rainfall it will not regenerate itself naturally. The upper limit of average rainfall is not known, but it must be pretty high, probably well over 100 in. per annum, provided the soil does not get water-logged.

Roughly speaking, the warmer and the more humid the conditions, the better Mvule will grow. I do not think there is any altitude limit, but 4,000 ft. is about as cold as it will stand normally in East Africa (I have seen this apply in the Rungwe District of Tanganyika Territory, in parts of Kenya, and all over Uganda). I have seen it growing well in sheltered, sunny localities above the 4,000 ft. contour, but such cases must be regarded as exceptions rather than the rule.

NATURAL REGENERATION

Mvule regenerates naturally by two methods:—

By suckers from the surface roots, particularly if they are damaged in any way. So far as I can see, and I am referring only to the deep red loams, the lower limit of average rainfall for this type of regeneration is somewhere about 45 inches per annum. Damage under natural conditions presumably only occurs when animals are burrowing or through some local subsidence. In artificial conditions, such as in cultivated land, any severing of the surface roots, as by plough or hoe, can start sucker regeneration. Under such conditions railway and road cuttings are often a cause of prolific sucker regeneration. Since under good conditions surface roots can travel up to 200 yards from the parent tree, it is clear that sucker regeneration can occur over an area of 26 acres with that tree as the centre.

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* This botanical information was supplied by P. J. Greenway, Systematic Botanist, Amani.

By seed.—The fruit is like a large, green, elongated mulberry. Both fruit-eating birds and bats help to spread the seed. It is unlikely that these pass through the alimentary canals of these creatures; probably parts of the flesh of the fruit with seeds adhering fall to the ground uneaten. The seeds seem to germinate best in the moisture of their own fruit. Once germination has occurred, however, only a very special set of conditions will ensure the continued life of the seedling. The soil must be continuously moist, though not waterlogged, until the seedling has fully established itself. Therefore, either shade or considerable atmospheric humidity, coupled with good daily rainfall, is essential lest the soil dry out. There must be little or no root competition and a reasonable tilth is required. The shade of banana plants seems to fulfil these conditions.

The seedling is very small, as one would naturally expect to be the case with such a small seed, and it is also very delicate. It is subject to the attacks of crickets, cutworm, etc. A severance of the leader above the first pair of true leaves often results in the formation of a branch type leading shoot. This is indicated by the leaves lying in one plane on either side of the stem, and by the stem itself bending over towards the ground. If the leading shoot is damaged the seedling reacts slowly. A new leader may form at any suitable place along the remaining portion of the shoot. Often a branch-type leader is formed. It may be recognized by its leaves which lie in one plane on either side of the slender stem, and by the stem itself bending over towards the ground. The resulting distortion may check normal growth for several years. A true leader grows vertically and is straight and thick with leaves growing in a well marked pattern around it.

ARTIFICIAL REGENERATION FROM SEED

The best nursery soil, I find, should be as light as possible and very friable, amounting almost to sand, provided there is a good supply of humus. It must be at least four feet deep. An abundant, all-the-year-round water supply in the nursery is, of course, essential.

The fruit is collected from the ground in April, crushed in the fingers, and broadcast thickly over the seed bed within a fortnight of collection. Soil is lightly sifted over this, just sufficient to cover the seed. The bed is given no shade whatsoever, as it is watered at least twice a day. The seedlings should come up like cress.

Pricking out should be done as soon as the first true leaves are fully formed. Delay after that often results in the death of the plant. The seedlings are pricked out into lines 18 inches apart. No shade is given for fear of drip, of which the seedlings are quite intolerant.

Crickets and other insects are dealt with in the following way:—

Take half an ounce arsenate of lead, pour it into a *kalai* (mortar pan) half full of cold water and stir until dissolved. Add *posho* (maize meal), stirring the while until the whole is sufficiently solid easily to be picked up in the hand. Place a small knob, about the size of a walnut, in the centre of each square formed by the pricked-out seedlings. The insects are attracted by this bait and are quickly poisoned. By the time a fresh invasion of insects has occupied the ground, the Mvule are beyond their reach and the delicate tops are out of harm's way.

[*Note.*—Lead arsenate is poisonous to man, beast and Mvule, so make the mixer wash his hands thoroughly after work, keep children and dogs away from the nursery, and do not let the bait come within six inches of the young Mvule seedlings.]

Given the type of soil mentioned above, well mulched and watered daily, the seedlings should be 18 inches to 24 inches high by the end of December. From then on the height growth becomes really prodigious, provided that the axillary buds are nipped off. By June of the following year the average height should be 6 feet, occasional trees up to 11 feet or 12 feet. Weeding, loosening of the top soil (for aeration), mulching and watering should be kept up, and by January of the second year the average height should be 8 feet to 12 feet. Once the tops are out of reach, nipping of the axillary bud should be discontinued for fear of breaking the plant when it is bent down.

The gall-fly can be kept within reasonable bounds or even suppressed either by spraying with D.D.T. or Gammexane—I.C.I. 666 solutions, or by puffing "Geetox" (obtainable from Atlantic Products, Ltd., P.O. Box 390, Nairobi). Spraying or puffing should be carried out weekly.

ESTABLISHMENT

The best way to establish Mvule has been found to be by the use of "Stocks" 8 feet or more. A stock is a stripped plant with all the green shoot cut off. These stocks are usually planted out at the beginning of the long rains at the ultimate spacing, because there is no sale for Mvule thinnings, and because it is largely self-pruning.

The best spacing is probably round about 40 feet x 40 feet, but anything from 30 feet x 30 feet to 50 feet x 50 feet is worth trying.

The advantage of using well developed stocks for planting greatly outweigh the disadvantages. The trees all remain under personal supervision in the nursery so that over 95 per cent establishment should be obtained in the first year; the leader is right from the start well above animal browsing height (buck like to eat Mvule leaves). It is at the time of planting a quarter of the way towards the gall-fly "ceiling"; the large volume of extra food reserves enables vigorous height growth to be produced in the first year; finally, with so few trees to the acre, transport from the nursery ceases to be a very serious problem. One high-sided lorry can carry about 500 stocks if they are packed head to tail like sardines. At 40 feet x 40 feet spacing this is enough for about 20 acres.

In early youth Mvule will stand a small amount of top shade, though it prefers to be in the open, but it is intolerant of side shade. Nurse trees with clean stems are, therefore, about all it will stand, and then only if there is little or no root competition. It will not tolerate drip. When under shade Mvule produces a leaf form very different from that when it is out in the open. It is longer, slightly broader, lighter in colour, and probably one pallisade cell layer thinner. It is, in fact, almost unrecognizable as an Mvule leaf.

Under forest conditions natural regeneration from seed is rare and the young tree takes a long time to struggle up into the top canopy. This struggle is often marked by a decided etiolation of the stem coupled with considerable crookedness due to checks and die back through overshading and drip. In the long run, however, the stem straightens itself and thickens out into magnificent boles, but from an economic point of view this takes up valuable time.

In the open the young plants are often attacked by the gall-fly (*Phytolyma lata*). Galls are caused by the distorted growth of the meristematic tissues around and near the eggs of the fly. The gall is particularly noticeable when the trees are not in first class condition. The "ceiling" of the gall-fly appears to vary from place to place, but seldom seems to be much more than 30 feet above the ground. The fly has several natural parasites, but unfortunately these have apparently resided in their hosts for a very long time and the fly is completely tolerant of them. Biological control can, therefore, be regarded as unlikely. The fly does not like shade, but unfortunately Mvule will not grow rapidly under sufficient shade to discourage the fly from depositing its eggs. Luckily, under conditions of the soil type mentioned earlier in these notes coupled with reasonable rainfall, Mvule grows so fast and so vigorously that gall-fly attacks when they do occur are by-passed and the all-important apical meristem is unaffected. In fact, the fly seems to avoid depositing its eggs on healthy plants.

When regenerating artificially, therefore, one has to aim at (*a*) producing really healthy plants, and (*b*) inducing as rapid height growth as possible. In plantations the latter should not be at the expense of crown production. That is to say, axillary buds should not be nipped, otherwise bleeding and consequently loss of vitality will occur. Multiple stems cannot, of course, be allowed.

Mvule is intolerant of conditions which prevent free access of air to the surface roots. From about six to ten years of age, i.e. when it reaches about 24 inches girth at breast height, large surface roots are produced in addition to the deep, water collecting roots. These surface roots are covered with pores, through which interchange of gases takes place. It stands to reason, therefore, that any vegetation which tends to compact the top soil or to compete with the surface roots for top soil moisture has an adverse effect upon the tree. Most grasses, particularly those with strong rhizomes, are detrimental to Mvule growth. Couch grass is, of course, deadly. Where, as at Mlingano Sisal Experimental Station, Tanga Province, other conditions are at their optimum, Mvule will stand a certain amount of soil compaction or surface root competition, but only at the expense of rapid growth.

From this it is obvious that grass and weed suppression, either by direct cultivation or by the introduction of grass and weed suppressing plants, must be carried out. Given sufficient soil moisture (usually sufficient, with a well distributed rainfall) any species, which keeps down the grasses and weeds and which itself does not compete unduly with the Mvule will suffice as a nurse or understory plant.

CULTIVATION

Since Mvule roots must have aeration, cultivation is absolutely essential until the large surface roots have formed and the tree is able to look after itself. This cultivation is an expensive business, and is, therefore, best carried out in conjunction with the growing of other crops. In this connexion it should be pointed out that banana plants and Mvule appear to be mutually beneficial. Apparently the banana plant, which is a voracious but a surface feeder, draws its nourishment largely from the mulch of leaves dropped from the Mvule, and the Mvule enjoys the clean floor and the mulch of the decaying banana leaves and stems.

During early youth artificial mulching of the Mvule is beneficial in addition to cultivation.

PLANTING METHODS

Very great care should be taken while planting to tamp the earth tightly round all the roots and rootlets. In Uganda, so Mr. Webb, Senior Forester, informs me, two gangs are employed. The first places the stock in the hole already prepared and rams the earth round only the lower roots, and this work is inspected before the remainder of the hole is filled in and tamped hard by the second gang. This method, states Mr. Webb, ensures a very high percentage of establishment.

SPACING

There is room for some experiments to ascertain the best spacing for Mvule under varying conditions of soil, average temperature, humidity and soil moisture.

CROWN FORMATION

Mvule takes about two years to react strongly to altered conditions. Thus crown formation does not become obvious until the second growing season after planting. This also applies where Mvule is freed from difficult conditions, such as compacted top soil, grass cover, or excessive surface root competition. It takes young Mvule about two years before signs of favourable reaction occur. A good crown in early youth should always be aimed at, even though height growth may not be as rapid as one would hope. A good crown means a strong, healthy plant, with plenty of reserves of food in the stem and rootstock. Once this has been attained the tree will put on its height growth without any encouragement from man.

GALL IN THE PLANTATION

Spraying of trees has been tried but the results have not proved economic. The best prevention is to grow Mvule only under the optimum conditions, so that they are so healthy that the fly leaves them alone, or, if the trees are attacked, they easily by-pass the affected part and continue growing.

RATE OF GROWTH

Rate of growth varies enormously, particularly in the cases of differences in soil type, average rainfall, and root and sunlight competition. Under optimum or near optimum conditions Mvule grows very rapidly indeed, as witness a stump planted in the Sokoke Coconut Estate, Kilifi, Coast Province, Kenya, in April, 1939. The average rainfall here is 46 inches and the soil a deep, red loamy sand, as already described. The tree was kept cultivated. By eight and a half years later the girth at breast height was 2 feet 8½ inches and the height as measured by hypsometer 37 feet. Growth on the Sisal Experimental Station, Mlingano, Tanga Province, is probably even more rapid.

UNDERPLANTING

So far as I am aware there is no reason why a limited number of selected timber species should not be introduced under Mvule once the latter are really well established, say as soon as surface root formation has commenced. Such trees should not be fast growing species, however, or their voracity might adversely affect the Mvule. Suggested species are *Afzelia quanzensis*, *Erythrophloeum guineense*, *Macrolobium coeruleum*, and perhaps *Trachylobium verrucosum*, provided that experiments show the last named to be a reasonably slow grower. All these species thrive under similar conditions. One would not expect to get a great deal of timber from them, but they would add to the total profits at felling time.

THE SOLIDS-NOT-FAT OF KENYA MILK

By H. M. Nefdt and F. McNaughtan, Government Chemist's Department, Kenya

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In July, 1946, a paper entitled "The Constituents of the Solids-not-fat of Kenya Milk" by H. S. Purchase and A. A. Reverberi of the Veterinary Research Laboratory, Kabete, was published in the *East African Agricultural Journal.*

The relevant findings of the authors were:—

(1) That the solids-not-fat were often below the presumptive minimum required by law, i.e. 8.5 per cent. Of the samples analysed, 51 or 78.5 per cent failed in this respect.

(2) That the solids-not-fat figures were often extremely low, 41 or 63 per cent of the samples being below 8.25 per cent, and 21 or 32 per cent below 8.0 per cent.

(3) That the deficiency in the solids-not-fat was not confined to any particular breed, but occurred at times in all breeds from which samples had been obtained, namely, Friesian, Ayrshire, Shorthorn, Guernsey, Red Poll, Mixed Grade, Native Grade and Native.

These results are in conflict with the findings of this department, based on the examination of milk samples under the Foods and Drugs (Adulteration) Ordinance, over several decades. The quality of Kenya milk, as represented by the public supply in Nairobi, had been found to be of a high standard, and with the exception of milk from Friesian herds, complied without difficulty with the legal requirements. That the milk of Friesian herds, particularly from lush areas such as Limuru, could fail in solids-not-fat had been known and accepted for many years, and due allowance had been made for such supplies. The solids-not-fat of Friesian milk, however, had very seldom been found to fall below 8.2 per cent, i.e. a 3.5 per cent deficiency, whereas in the above-quoted paper the solids-not-fat of Friesian milk was found to fall as low as 7.43 per cent, i.e. a deficiency of 12.5 per cent.

In view of the legal repercussions which the findings of this paper might have in the enacting of the Foods and Drugs (Adulteration) Ordinance, it was felt that these differences should be investigated. A meeting was accordingly convened under the Chairmanship of the Director of Medical Services to discuss the matter. It was agreed that a check-survey of Kenya milk was indicated, and this work was assigned to the Government Chemist's Department.

The investigation was commenced in November, 1946. Morning and evening samples from as many herds as possible were obtained, and the results are separately tabulated under the different breeds.

As this investigation was concerned primarily to determine the quality of Kenya milk from the legal aspect, the determinations were limited to the estimation of fat and total solids, the solids-not-fat being obtained by difference.

The fat was determined by the official Gerber method, and the total solids by weight. Formaldehyde was used as preservative.

FRIESIAN

Serial No.	Herd	Area	Month	Fat	Solids	Solids-not-fat
			1946	%	%	%
1	High Grade	Kikuyu . .	Nov.	3·35	11·43	8·08
				3·35	11·55	8·20
2	Grade . .	Naivasha	Nov.	3·95	12·34	8·39
				4·15	12·77	8·62
			1947			
3	High Grade	Kinangop	Jan.	3·50	11·89	8·39
				3·80	12·32	8·52
4	Grade . .	Uplands	Jan.	4·20	12·60	8·40
				5·20	13·42	8·22
5	High Grade	Naivasha	Jan.	3·60	12·25	8·65
				3·90	12·85	8·95
6	Pure Bred	Naivasha	Jan.	3·75	12·31	8·56
				3·80	12·21	8·41
7	High Grade	Gilgil . .	Mar.	3·90	12·53	8·63
				4·70	13·60	8·90
8	Pure Bred	Naivasha	April	3·65	12·42	8·77
				4·05	12·60	8·55
9	Grade . .	Uplands	May	4·70	13·11	8·41
				4·80	13·13	8·33
10	Grade . .	Limuru . .	June	4·40	12·61	8·21
				5·90	13·99	8·09
11	Grade . .	Kinangop	Aug.	3·80	12·19	8·39
				3·90	12·05	8·15
12	Pedigree . .	Limuru . .	Aug.	3·90	12·40	8·50
				4·10	12·40	8·30

SOLIDS-NOT-FAT

Number of Samples	Below 8.5 per cent.	Below 8·25 per cent.	Below 8·0 per cent.
24	14 or 58·3%	6 or 25%	Nil

AYRSHIRE

Serial No.	Herd	Area	Month	Fat	Solids	Solids-not-fat
			1946	%	%	%
1	Grade	Ulu	Nov.	4·70 5·25	13·79 14·11	9·09 8·86
2	High Grade	Mua Hills	Dec.	4·30 5·35	13·08 13·90	8·78 8·55
3	Grade	Kitale	Dec.	4·45 4·70	12·82 13·15	8·37 8·45
4	High Grade	Elmenteita	Dec.	3·81 4·18	12·24 12·30	8·43 8·12
5	Grade	Ruaraka	Dec.	4·30 5·20	13·16 14·03	8·86 8·83
6	Grade	Ulu	Dec.	3·95 4·40	12·74 12·94	8·79 8·54
7	Pure and High Grade	Njoro	1947 Feb.	3·70 4·30	12·24 12·92	8·54 8·62
8	Grade	Gilgil	Mar.	4·20 4·25	12·80 12·66	8·60 8·41
9	Grade	Kinangop	Mar.	5·15 4·53	13·87 12·86	8·72 8·33
10	Grade	Gilgil	April	4·20 4·65	12·96 13·30	8·76 8·65
11	Grade	Kikuyu	April	4·60 3·80	13·68 12·48	9·08 8·68
12	Grade	Limuru	April	4·25 4·80	12·99 13·64	8·74 8·84
13	High Grade and Grade	Kabete	May	5·10 4·45	14·11 13·52	9·01 9·07
14	Grade	Limuru	May	3·80 4·60	12·57 13·34	8·77 8·74
15	Pedigree	Naivasha	May	4·35 4·70	13·07 13·35	8·72 8·65
16	Ped. and Gr.	Limuru	June	4·40 4·90	12·77 13·24	8·37 8·34
17	Pedigree	Nairobi	June	4·80	13·31	8·51
18	Grade	Nairobi	June	4·50	13·26	8·76
19	Grade	Ngong	July	4·90 4·35	13·71 13·42	8·81 9·07
20	Grade	Ulu	July	4·00 4·25	13·04 12·82	9·04 8·57
21	Pedigree	Kinangop	July	4·40 4·75	13·20 13·59	8·80 8·84
22	Gr. Ayrshire	Naivasha	July	3·95 4·40	13·19 13·19	9·24 8·79

SOLIDS-NOT-FAT

Number of Samples	Below 8·5 per cent.	Below 8·25 per cent.	Below 8·0 per cent.
42	8 or 19%	1 or 2·4%	Nil

MIXED HERDS

Serial No.	Herd	Area	Month	Fat	Solids	Solids-not-fat
			1946	%	%	%
1	H. G. Frn./ Shorthorn	Limuru	Nov.	3·90 4·85	12·12 12·89	8·22 8·04
2	H. G. Frn./ Ayrshire	Longonot	Dec.	3·60 4·60	12·10 13·18	8·50 8·58
3	H. G. Frn./ Ayrshire	Longonot	Dec.	4·10 4·55	12·82 13·00	8·72 8·45
4	Gr. Shorthorn/ Ayr.	Thomson's Falls	1947 Jan.	3·60	12·69	9·09
5	Gr. Shorthorn/Kerry	Songhor	Feb.	4·50 4·85	13·51 13·85	9·01 9·00
6	Gr. Jersey/ Ayr./ Frn.	Limuru	May	4·35 4·65	12·85 13·24	8·50 8·59
7	Mixed Gr.	Ruaraka	May	3·90 3·50	12·50 12·00	8·60 8·50
8	Gr. Ayrshire/ Shorthorn	Naivasha	June	4·40 5·00	14·10 14·42	9·70 9·42
9	G. Frn./Red Poll	Naivasha	June	3·60 3·70	12·38 12·14	8·78 8.44
10	Gr. Ayrshire/ Shorthorn	Limuru	June	4·30 4·40	13·09 12·96	8.79 8.56
11	Gr. Ayrshire/ Shorthorn	Limuru	June	4·30 4·75	13·22 13·52	8.92 8.77
12	Gr. Ayrshire/ Frn./ Guer.	Naivasha	June	4·40 4·85	13·10 13·61	8.70 8.76
13	Gr. Sh./Red Poll	Athi Riv.	June	5·15 4·90	14·55 13·91	9·40 9·01
14	H. G. Ayr./ Shorthorn	Kiambu	June	5·80 5·30	14·27 13·95	8·47 8·65
15	G. Ayr./Short	Limuru	July	4·40 4·60	12·90 13·28	8·50 8·68
16	Ayr./Short.	Gilgil	July	4·20 4·50	13·17 13·51	8·97 9·01
17	Ayr./Frn./ Jersey	Limuru	July	4·80 5·35	13·69 13·92	8·89 8·57

It is to be noted that except in one instance (No. 14) the deficiencies in this group occurred only where Friesian cows formed part of the herd.

SOLIDS-NOT-FAT

Number of Samples	Below 8·5 per cent.	Below 8·25 per cent.	Below 8·0 per cent.
33	5 or 15·1%	2 or 6·1%	Nil

OTHER BREEDS

Serial No.	Herd	Area	Month	Fat	Solids	Solids-not-fat
			1946	%	%	%
1	High Grade Guernsey	Nakuru	Nov.	5·60	14·40	8·80
				5·25	13·96	8·71
2	Gr. Jersey	Naivasha	Nov.	5·20	14·24	9·04
				5·45	14·45	9·00
3	Gr. Shorthorn ..	Naro Moru	Nov.	4·40	13·48	9·08
				4·10	12·89	8·79
4	Dairy Short.	Ngong ..	Nov.	4·00	12·94	8·94
				4·50	13·34	8·84
5	Dairy Short.	Nakuru	Dec.	3·25	12·08	8·83
				3·35	11·90	8·55
6	Gr. Jersey	Naivasha	Dec.	5·70	14·59	8·89
				5·10	14·08	8·98
			1947			
7	High Grade Red Poll	Njoro ..	Jan.	4·25	13·23	8·98
				3·75	12·74	8·99
8	Native (Boran)	Ngong ..	Jan.	5·60	14·90	9·30
				7·80	16·63	8·83
9	Native (Juba) ..	Mariakani	Feb.	4·50	13·02	8·52
				5·40	14·08	8·68
10	Guernsey ..	Kikuyu..	Feb.	4·10	12·68	8·58
				4·35	12·88	8·53
11	Guernsey ..	Kikuyu..	Mar.	4·50	13·08	8·58
				3·90	12·60	8·70
12	Native ..	Mariakani	Mar.	5·80	15·34	9·54
				5·20	14·81	9·61
13	Native (Juba) ..	Mariakani	April	5·60	14·59	8·99
				6·10	15·07	8·97
14	Shorthorn	Songhor	May	4·00	13·06	9·06
				5·40	13·92	8·52
15	Gr. Red Poll	Njoro ..	May	4·00	13·03	9·03
				4·65	13·70	9·05
16	Gr. Shorthorn ..	Gilgil ..	June	5·10	14·61	9·51
				4·30	13·33	9·03

SOLIDS-NOT-FAT

Number of Samples 32 ......No deficiencies.

The final analysis of the solids-not-fat figures for both surveys, is set out below.

	No. of Samples	Below 8·5%	Below 8·25%	Below 8·0%
Purchase and Reverberi ..	65	51 or 78·5%	41 or 63%	21 or 32%
Nefdt and McNaughtan ..	131	27 or 20·6%	9 or 6·9%	Nil

Examination of those samples which fell below 8.5 per cent solids-not-fat show them to be mainly in the Friesian group; only one sample other than Friesian or mixed Friesian (No. 4 Ayrshire) fell below 8.25 per cent.

CONCLUSION

The results of this survey have confirmed the previous findings of this Department as regards the solids-not-fat content of Kenya milk.

Note.—Since the completion of this investigation, a comprehensive list of Friesian breeders has been received from the Friesian Cattle Breeders' Society.

As a large proportion of these are not represented in this survey, and as a fuller investigation of Friesian milks would appear justified, it is proposed that this should constitute the subject of a separate survey, which is now in progress.

THIOPHOS 3422

A new chemical compound, Thiophos 3422 insecticide, is effective against a wider range of insects, mites and other lower invertebrates than any chemical now in practical use. This includes nicotine, rotenone, D.D.T., and other compounds. In fact, no species of insect or mite among those tested has been found resistant to its toxic action in the laboratory, at concentrations comparable to those now used for control by known insecticides. Thiophos 3422 insecticide has been developed by the American Cyanamid Co., and will be available in 1948. Thiophos 3422 insecticide is o, o-diethyl o-p-nitrophenyl thiophosphate. Uncovered by British and American scientific teams at the close of hostilities in Germany, this compound had been designated E 605 by the Germans, who had tested it briefly, but had never developed a satisfactory method of producing it commercially.

Extracted from *Chemistry and Industry*, January 10th, 1948, p. 32.

LOCAL MILLETS AS SUBSTITUTES FOR MAIZE IN THE FEEDING OF DOMESTIC ANIMALS

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As a result of changing social conditions greater quantities of maize are being sought, for nutritional purposes, by Africans who formerly lived largely on millets. Consequently many marginal areas, which receive only a small or a badly distributed rainfall and which are therefore more suited for millet production are now being planted with maize. As would be expected, the yields are erratic and unreliable and there is a greater demand for maize grown in the normal maize-producing areas. During recent years flourishing poultry and pig producing units have been built up, and the chief foodstuff demanded by these enterprises is maize meal. A vicious circle is therefore being created by the greatly increased demands for maize for both human and animal nutrition whilst at the same time, because of the increasing tendency to plant maize on land which should be seeded with millet, the production of millet is lower and this deficit imposes a further demand on the available maize supplies.

If, as is anticipated, there is a continued increase in the demands for these foods, the maximum amount of maize and millet grains will have to be produced and, to achieve this, potentially good millet-producing land should not be planted with maize. African nutritional requirements will probably draw increasingly on the maize grown in suitable maize-producing districts and this will be followed by a greater diversion of millet grains, from the areas suitable for millet growing, to help meet the needs of enterprises producing animal products. The feeders of live stock in East Africa are not all familiar with the nutritive values of the various local millet grains nor of the extent to which they can replace maize in animal rations. The object of this article is therefore to indicate to what classes of livestock and in what quantities millet grains can be successfully fed. It also describes the results of experiments, conducted at the Mpwapwa Veterinary Research Laboratory, Tanganyika, on the feeding value of local white millet (*mtama*) and Bulrush millet (*mawele*).

Examination of the limited literature available reveals that millets can be fed successfully to cattle, horses, sheep, pigs and poultry and that the different varieties differ somewhat in nutritive value. On the whole, however, millet can be assessed at approximately 90 per cent of the energy value of maize meal provided the millet does not form an unduly high percentage of the total ration.

BEEF CATTLE

In the southern parts of the Great Plains region of U.S.A. the grain sorghums play a very important part in the feeding of beef cattle and have been found to produce almost as rapid liveweight gains as maize. Henry and Morrison [1] quote the results of three feeding trials in which approximately equal weights of grain and alfalfa hay were fed to steers. In one set of experiments ground maize was fed and in the other set Kaffir corn. It was found that the Kaffir corn had 87 per cent of the feeding value of maize meal. Further experiments in Texas [2] and New Mexico [3] indicated that grain sorghums compare favourably with maize for beef production.

Millet grains, because of their small size, should always be fed ground to oxen, otherwise an appreciable quantity of the whole grains will escape mastication and digestion and will pass undamaged through the alimentary tract into the faeces.

DAIRY COWS

Grain sorghums are a source of cheap carbohydrate concentrate to dairymen in the arid South Western States and are reported by Henry and Morrison [1] to be only 5–10 per cent less valuable than maize for milk production, provided the grains are ground before feeding. White Millet, after grinding, has been successfully employed at Mpwapwa for replacing half the maize meal in the concentrate mixture fed to milking and dry cows.

When feeding cows it is essential that millet grains should be ground before feeding and should be fed in a properly balanced ration. Like maize, millet grains are low in lime and proteins and the latter have a low food value unless supplemented by other foodstuffs capable of correcting the amino-acid balance.

CALVES

Millet grains can replace maize in the rations of calves and are particularly useful when teaching young animals to eat solid foodstuffs.

SHEEP

Large numbers of sheep in the millet-producing belt of the States are fed millet grains with satisfactory results. Henry and Morrison [1] quote experiments in Kansas and Texas which indicate that it is hardly necessary to grind sorghum grains before feeding them to sheep. French [4] has also determined the feeding value of uncrushed East African white and bulrush millets for local sheep with the following results:—

	Digestible Protein	*Starch Equivalent*
Crushed maize	7.0	79.0
Uncrushed white millet	8.3	76.9
Uncrushed bulrush millet	7.0	61.6

Even though unground, white millet has practically the same nutritive value as maize meal but, owing to their much smaller size, whole bulrush millet grains were less digested and a fair percentage passed whole into the faeces. With this small-sized grain it can be anticipated that grinding would bring its feeding value more nearly into line with that of crushed maize. In the above trials approximately equal weights of grain and local hay were fed. For sheep, local millets can be regarded as having the same feeding value as maize meal particularly if the millet grains are crushed before feeding.

GOATS

No information can be gathered, from the limited literature available, on the feeding value of millets for goats but for many years ground white millet, at 20 per cent of the total concentrate mixture, was successfully fed to milking goats at Mpwapwa.

HORSES, MULES AND DONKEYS

Millets should always be coarsely ground or preferably rolled before feeding to these animals, otherwise many of the hard-coated small grains will escape digestion. On the other hand, if ground too finely, pasty indigestible lumps can form in the stomach. Millet grains tend to be costive, and it is a good plan to feed the rolled or crushed grains mixed with bran. They are somewhat less valuable than maize for this class of animals and do not have the superlative quality of oats but they can play a useful purpose in times of maize shortage. At Mpwapwa, they were used on occasion to replace up to 50 per cent of the maize ration but should normally not replace more than 25 per cent of the maize.

Although, as indicated above, considerable quantities of maize can be saved by substituting millet for maize in the rations of the larger domestic animals, by far the greatest use of these grains in animal nutrition is in the feeding of poultry and pigs, and it is for these animals that millets are particularly advocated in East Africa.

POULTRY

Millet grains are extensively used in parts of U.S.A. for feeding to poultry, and experience at Mpwapwa and elsewhere has shown that local millet grains are well liked by and of high feeding value for poultry (i.e. hens, ducks and turkeys). The grains can either be fed whole, as part of a scattered grain ration, or can be ground and incorporated in a mash. Experience with flocks of high yielding European hens [5] and with native and half-grade birds [6] at Mpwapwa suggested that there was little, if any, difference in feeding values for poultry between bulrush millet, white millet and maize. When used at the rate of 20–25 per cent of the total ration, ground white and bulrush millets allowed flock averages of over 200 eggs per year [5] and on occasion, when maize was unprocurable for short periods, ground millets forming 60 per cent of the total ration were fed without causing any drop in egg yields. It is probable that these local millets could be fed over long periods, as a normal constituent of poultry rations at at least 40–50 per cent of the total ration. Millets are also very useful in mixtures for fattening and breeding birds, and bulrush millet, unground, is very valuable for feeding to young chicks.

PIGS

Locally produced white and bulrush millets are very valuable pig foods but should always be ground or crushed, otherwise large quantities of grain, particularly of bulrush millet, will pass undigested through the animals and appear unaltered in the faeces. This was made abundantly clear in tests by French [7] at Mpwapwa. Pigs were fed whole white and bulrush millet grains and the digestibility and feeding values were determined. These are compared below with other figures recorded by French [8] for crushed maize, and in both millet trials undigested grains were present in the faeces in large quantities.

	Digestible Crude Protein	*Starch Equivalent*
Crushed maize ..	9.64	80.18
Whole white millet ..	7.57	61.62
Whole bulrush millet	8.54	59.52

The voiding of undigested grains undoubtedly contributed very largely to the much lower feeding values of the whole millet grains when compared with crushed maize, since the compositions of the three grains were very similar.

COMPOSITION ON DRY MATTER BASIS

	Maize	*White Millet*	*Bulrush Millet*
Crude protein ..	12.33	12.04	14.07
Ether extract ..	3.71	3.43	4.53
N-free extract ..	79.77	77.68	76.35
Crude fibre ..	2.67	4.78	3.13
Silica—free ash ..	1.68	1.73	1.46

Not only must millet grains be ground before feeding to pigs but, because of their deficiencies in certain minerals and amino-acids, they must be fed in properly balanced rations, otherwise their full value is lost. It is also probable that the nutritive value varies with the particular type of millet fed, and American figures indicate that, in balanced rations, millets possess between 90 and 95 per cent of the feeding value of maize for bacon production.

In South Africa, Murray and co-workers [9] found that if ground millet replaced half the crushed maize in the standard pig ration of 90 per cent maize meal and 10 per cent meat meal, greater daily liveweight gains and a more (10 per cent) economical conversion of food into liveweight increase were obtained. In this particular experiment it would appear that millet had 110 per cent of the feeding value of maize but it is probable that the mixed ration was more palatable and that the maize portion was more efficiently used. It would be safe to assume, however, that the particular millet had at least as high a feeding value as maize.

Attempts were made at Mpwapwa to feed pigs with large quantities of white millet and with this grain replacing the whole of the maize in the rations. The results of these pig feeding experiments are summarized below:—

RATIONS FED IN THE DIFFERENT TRIALS

	Ration H	Ration M	Ration HM	Ration HB	Ration S
Maize Meal ..	52	25	—	52	60
Crushed White Millet ..	—	60	52	—	—
Rice Polishings ..	20	—	—	—	—
Crushed Cowpeas	20	—	20	20	15
Wheat Bran ..	—	—	20	20	15
Meat Meal ..	5	12	5	5	7
Lime ..	2	2	2	2	2
Salt ..	1	1	1	1	1

RESULTS OF FEEDING TRIALS

	Food Consumed per lb. Liveweight increase	Average Daily Liveweight increase	Number of Days Feeding
	lb.	lb.	
Ration H	2·92	1·35	128
Ration H + separated milk ..	2·46	1·62	107
Ration M	3·51	1·09	145
Ration M + separated milk ..	2·47	1·51	117
Ration H.M. ..	3·81	1·03	168
Ration H.B. ..	2·89	1·29	132
Ration H.B. + separated milk ..	2·49	1·57	120
Ration S	2·90	1·39	133

In all trials the pigs were fed from weaning until bacon weight at approximately 200 lb. liveweight and as far as possible the pigs on the different rations were comparable in that litter mates were divided amongst the different rations.

A previous paper, French [10], has demonstrated the great value of separated milk for improving the palatability of rations for pigs and for increasing the efficiency of food conversion into body weight out of all proportion to the nutrient material added in the milk. The first conclusion to be drawn from the trials in which milk was fed, is that ground white millet was fully equal to crushed maize in feeding value whether the millet replaced maize completely or only in part of the ration.

When the trials with rations H, HM and HB were being conducted it was observed that the replacement of the whole of the crushed maize by ground millet did not affect the rates of food consumption and liveweight increase for the first 2–2½ months' feeding but that, after this interval, the millet ration became unappetizing and the daily food consumption fell significantly so that for the whole feeding period the rates of liveweight increase and the economy of food conversion were very much lower for the millet fed pigs. Similar, though less striking results were obtained when feeding ration M.

It was apparent, from the trials with rations M and HM, that, when feeding millet at 50–60 per cent of the total ration, appetite may be lost and, if this happens, much more food has to be consumed to keep the animals alive and very little of the low daily intake is utilized for production purposes. In order to show how serious this loss may be, the values of millet (as a percentage of the feeding value of maize meal) for bacon production have been calculated from the results of these Mpwapwa trials. From trials HM and HB, when millet completely replaced maize at 52 per cent of the total ration, millet had 76 per cent of the feeding value of maize. From trials H and HM, when millet completely replaced maize at 52 per cent of the total ration, millet had 77 per cent of the feeding value of maize. From trials H and M where millet replaced only about half of the maize but the whole of the other grains and from trial S where part of these other foods only were replaced, millet had 86 per cent the feeding value of maize.

When these results are compared with the American, South African and the Mpwapwa trials when feeding separated milk, it is obvious that much care must be taken when feeding millet to pigs to ensure that the palatability of the ration is not impaired. Provided the ration remains appetizing it is apparent that local white millet can replace maize meal without any reduction in the rates of liveweight gain or in the conversion of food into body weight. If separated milk is available, complete replacement of maize by millet can be carried out but, in the absence of milk it is probable that not more than half the maize meal should be replaced by ground millet.

RED MILLET

No reference has been made above to the feeding value of red millet; this is because early experience at Mpwapwa indicated that it was less palatable than white or bulrush millets and no further work was continued.

SUMMARY

From the above, it is obvious that locally grown white and bulrush millets can be used very successfully for replacing maize in the rations of all classes of farm livestock provided care is taken to see that the ration remains properly balanced and that the millet does not form an unduly high proportion of the total ration. For practical purposes, these millet grains may be regarded as having 90 per cent of the feeding value of maize but, as demonstrated above, they are fully the equivalent of maize for certain classes of animals and under certain conditions of feeding.

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SOME NOTES ON THE FOOD OF GOATS IN A SEMI-ARID AREA

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Surprise is frequently expressed at the ability of the goat to maintain itself in large numbers and in excellent condition in semi-arid country covered by the vegetation type known as "deciduous thicket", a vegetation type which during long dry periods contains very little foliage and practically no ground cover. The rainfall in such areas usually ranges from 12 inches to 20 inches per annum.

In order to find out exactly how goats are able to accomplish this, careful observations on feeding goats have been made over the past eighteen months and a summary of the information obtained is given in tabulated form. The whole of the information has been obtained from personal observation, as it has been found that native information on this subject is frequently erroneous. The list of species given is by no means complete, and further observation will undoubtedly extend the list, but it is probable that such extension will fall very largely within category "B" as regards palatability.

PALATABILITY

An attempt has been made to assess the relative palatability of the various species and in the attached table they are shown thus:—

"AA".—Extremely palatable and not left until every leaf within reach has been eaten.

"A".—Palatable; some little time spent before passing on.

"B".—An odd leaf or two snatched in passing, but no particular attention paid.

HABIT OF FOOD PLANT

The following abbreviations are used in the "habit" column:—

T.	tree.
SH.	shrub.
SC-SH.	scandent shrub.
SUB-SH.	sub-shrub.
CL.	climber.
H-CL.	herbaceous climber.
H.	herbaceous plant.

VERNACULAR NAMES

It has been decided not to give vernacular names, as not only do these vary from place to place within the same tribal area, but frequently the same name is given to a number of species having no botanical affinity.

DISCUSSION

Deciduous thicket untouched by man is regarded as a "climax community", and it is not until, through exploitation by man for fuel, building poles and clearance for cultivation, etc., when it occurs in the form of a "dis-climax community", i.e. a community that originates and is maintained by disturbance that it is capable of supporting a large goat population; it is the continual disturbance of the thicket by man that maintains the more palatable tree species in a coppicing form accessible to goats.

Of the sixty-seven species observed to be eaten by goats approximately 60 per cent fall in categories "AA" and "A", and of these approximately 50 per cent are medium to large trees whose leaves, except for the lower branches where the habit is pendulous, would normally be out of the reach of browsing goats. When the thicket is in full leaf flush, food is abundant, and apart from the species listed as having been observed to be eaten, it is probable that most species of *Acacia* and all species of *Combretum*, *Commiphora* and *Grewia* are palatable; this in itself would extend the list to within the region of one hundred species.

During the period of leaf flush goats were never seen to show the slightest interest in any grass species.

With the advent of the long dry season the picture is entirely different. At this time of the year, except along the major drainage lines and fringing the large dry sandy river beds, the thicket is for the most part devoid of leaf. Practically the only green plants are all members of the *Capparidaceæ* of the genera *Mærua*, *Thylacium*, *Boscia*, *Capparis* and *Cadaba*. Of these, *Mærua tricophylla* and a scandent armed *Capparis sp.* are palatable and have been placed in category "A"; one *Boscia*

No.	Food Plant	Natural Order	Habit	Palatability			Remarks
				AA	A	B	
1	Acacia benthamii Rochebr.	Mimosaceae	T		A		
2	„ mellifera Benth.	„	T		A		
3	„ pennata (L.) Willd.	„	SC. SH.		A		
4	„ senegal (L.) Willd.	„	T		A		
5	„ seyal Del.	„	T		A		
6	„ tortilis (Forssk) Christen.	„	T	AA			Fruits.
7	Acalypha fruticosa Forssk.	Euphorbiaceae	SH.			B	
8	Albizzia anthelmintica (A. Rich.) Brogn.	Mimosaceae	T		A		Flowers only observed as eaten.
9	Asparagus sp.	Liliaceae	SC. SH.		A		
10	Aspilia holstii O. Hoffm.	Compositae	H			B	
11	Balanites aegyptiaca Del.	Simarubiaceae	T		A		
12	Barleria sp. E.117	Acanthaceae	SUB-SH.			B	
13	Bauhinia tomentosa L.	Caesalpiniaceae	SH.		A		
14	Boscia hildebrandtii Gilg ex desc.	Capparidaceae	SH.			B	
15	Bridelia taitensis Pax & Vatke	Euphorbiaceae	T			B	
16	Capparis sp.	Capparidaceae	SC. SH.		A		
17	Cassia abbreviata Oliv.	Caesalpiniaceae	T			B	
18	Clerodendron johnstonii Oliv.	Verbenaceae	SC. SH.			B	
19	„ myricoides R.Br.	„	SH.		A		
20	Combretum aculeatum Vent.	Combretaceae	SC. SH.		A		Persistent fruits in 'A' category in dry season.
21	„ binderanum Kotschy	„	T			B	
22	„ denhardtiorum Engl. and Diels.	„	SC. SH.		A		
23	„ exaltatum Engl.	„	T		A		
24	„ sp. E. 123	„	T		A		
25	Commiphora boiviniana Engl.	Burseraceae	T		A		
26	Crotalaria sp. E. 157	Papilionaceae	SH.		A		
27	Delonix elata L.	Caesalpiniaceae	T			B	
28	Disperma kilimandscharica C.B. Cl.	Acanthaceae	SH.		A		
29	Entada flexuosa Hutch. & Dalz.	Mimosaceae	CL.			B	
30	Fagara sp.	Rutaceae	T			B	
31	Grewia bicolor Juss.	Tiliaceae	T		A		
32	„ kakothamnos K. Schum.	„	SH.	AA			
33	„ villosa Willd.	„	SH.		A		
34	Hermannia exappendiculata (Mast.) K. Schum.	Sterculiaceae	SUB-SH.			B	
35	Hibiscus micranthus L.	Malvaceae	SH.		A		
36	„ sp. E. 150	„	SUB-SH.			B	
37	Hoslundia opposita Vahl	Labiatae	SUB-SH.		A		Fruits and leaves eaten.
38	Indigofera garckeana Vatke	Papilionaceae	SUB-SH.		A		
39	Ipomoea hardwickwii (Spreng.) Hemsl.	Convolvulaceae	H. CL.		A		Flowers and leaves eaten.
40	Kaempferia aethiopica Benth.	Zingiberaceae	H			B	
41	Lawsonia inermis L.	Lythraceae	T		A		Riverine only.
42	Leucas neufliziana Courb.	Labiatae	SH.		A		
43	Maerua tricophylla Gilg.	Capparidaceae	SC. SH.		A		
44	Ochna stuhlmannii Engl.	Ochnaceae	T	A			
45	Ormocarpum sp.	Papilionaceae	T		A		
46	Pavonia zeylanica Cav.	Malvaceae	SUB-SH.			B	
47	Plumbago zeylanica L.	Plumbaginaceae	SH.		A		Riverine only.
48	Premna viburnoides A. Rich.	Verbenaceae	SH.		A		
49	Psychotria sp. E. 149	Rubiaceae	SH.		A		
50	Rhoicissus erythrodes Planch.	Ampelidaceae	CL.		A		
51	Rhynchosia flavissima Hochst.	Papilionaceae	H. CL.		A		Inflorescence particularly eaten.
52	Rubiaceae E. 94	Rubiaceae	CL.		A		
53	Salvadora persica Garcin	Salvadoraceae	T		A		Mostly riverine.
54	Sansevieria sp.	Liliaceae	H.			B	Fruits only.
55	Secamone sp.	Asclepiadaceae	CL.			B	
56	Solanum incanum L.	Solanaceae	SUB-SH.			B	
57	Steganotaenia araliacea Hochst.	Umbelliferae	T		A		
58	Sterculia rhyncocarpa K. Schum.	Sterculiaceae	T			B	
59	Strychnos sp.	Loganiaceae	T			B	
60	Talinum cuneifolium Willd.	Portulacaeae	SUB-SH.			B	
61	Tamarindus indica L.	Caesalpiniaceae	T			B	
62	Tephrosia sp. aff. T. nubica Bak.	Papilionaceae	SUB-SH.			B	
63	„ sp. E. 161	„	SUB-SH.			B	
64	Terminalia holstii Engl.	Combretaceae	T		A		
65	„ ruspolii Engl. & Diels.	„	T		A		
66	Thunbergia longisepala Rendle	Acanthaceae	CL.			B	
67	Triumfetta pentandra A. Rich.	Tiliaceae	SUB-SH.			B	

sp. is placed in category "B", but present observations have not shown goats to touch any of the Thylaciums. It is probable that the low-growing *Cadaba glandulosa* is palatable, although this has not actually been observed. *Combretum denhardtiorum* is a semi-evergreen of category "A", but occurs in quantity only in localized areas.

The ground at this time of the year has a thin and patchy covering of fallen leaves, and it is the dry leaves of the species eaten when green that form the bulk of goat feed during the dry season; goats are expert at sorting out palatable species even from amongst the dry litter.

The only feed falling in category "AA" during the dry season is the twisted pods of *Acacia tortilis*, and their value as goat feed can be gauged from the fact that individual ownership is frequently claimed over groups of these trees. Before the pods are ripe enough to fall it is the general practice of goat-herds to shake them down by hand.

Another important dry season feed is the dry winged fruits of *Combretum aculeatum* which persist on the branches long into the dry season; this is a scandent shrub, but where unsupported by other vegetation it is of pendulous habit and easily accessible to goats. At this time of the year also the flowers of the still leafless *Albizzia anthelmintica* are eaten with relish where within reach. Major drainage lines and the areas bordering on the dry sandy river beds are naturally much exploited during the dry season; the "A" category *Lawsonia inermis* and *Plumbago zeylanica* are confined to such localities.

It was originally intended to include a column "C" under "palatability" for common species untouched by goats, but this was abandoned. It might, however, be as well to mention two species (both sub-shrubs) if only for the reason that they are often found covering large areas of abandoned cultivation and eroded grazing land in pure stand. One is a *Barleria* with showy white or pale blue flowers which goats have never been seen to touch, and the other is a *Tephrosia* closely allied to *T. nubica*, included as a doubtful "B".

On only one occasion, and that during the dry season, was a goat ever seen to eat any species of grass, and that possibly a mistake while sorting out fallen leaves, nor were goats ever observed eating the bark of a main stem, although young twigs are frequently devoured together with leaves—this is certainly not in accordance with the erstwhile theory that goats spent most of their time pulling up grass by the roots and ring-barking young trees.

ACKNOWLEDGMENT

I am indebted to Mr. P. J. Greenway, Systematic Botanist, Amani, for the majority of the plant determinations.

BOOK REVIEW

PROCEEDINGS OF THE NAIROBI SCIENTIFIC AND PHILOSOPHICAL SOCIETY, Volume I, No. 1, November, 1947. Printed by the African Press, Ltd., Nairobi, for the Society. Price, Sh. 2/50.

Presumably owing to shortage of paper, this first number of the proceedings of the Nairobi Scientific and Philosophical Society contains only summaries of the papers and addresses given before the Society, and it is hoped that facilities will be available in the future to publish the complete texts. Nairobi is developing rapidly as the cultural centre of East Africa, and it is certain that this Society will play an important part in encouraging a broader outlook on science. In these days of high specialization, scientists tend to concentrate on a narrow field of view and they find it difficult to keep abreast of the advances in other branches of science, particularly in regard to their application to East Africa.

The papers summarized in the proceedings of the first year of the Society cover a wide range of subjects:—Radio-sonde in meteorology; the sociologist in industry; primitive agriculture in the modern economic world; development planning for the African; and hormone weed-killers. The Society intends to take full advantage of the presence of visiting scientists, and thus we may expect interesting views and impressions in later volumes of the Proceedings.

D. W. D.

DAIRY FARMING IN THE TSETSE FLY BELT OF THE ANGLO-EGYPTIAN SUDAN

By A. R. Staniforth, Inspector of Agriculture, Sudan Government

(*Received for publication on 4th March, 1948*)

Meridi dairy herd is an example of cattle-keeping in the tsetse fly belt in the extreme south-west of the Sudan. Complete records have been kept since the herd was started six years ago and it is the object of this short paper to provide some information, based on these six years' experience, regarding the possibility of keeping dairy cows in "fly" country. In addition, some information will be given on the milking potentialities of the cattle of the Southern Nilotics which graze up to the fringes of the Central African "fly" area. Some details on the breeding of these cattle at Meridi will also be given and very tentative conclusions drawn therefrom. An incidental note will be included on making butter at Meridi.

STAFF

In starting a herd in tsetse fly country one is faced with a complete lack of local knowledge of cattle—it is still possible to see local people in Meridi fleeing in terror from a straying calf. Milkers and herdsmen from the Nilotic, cattle-owning Dinka tribes were brought in from the north and, although several local milkers have been trained from time to time, it will take years of apprenticeship before local people can develop anything like the Dinka's cattle sense. The head Dinka cowman came with the first cows in 1941 and this continuity of management has been extremely valuable. The herd has also benefited from the supervision of a Northern Sudanese agriculturist with a knowledge of cattle, who has been stationed at Meridi since January, 1943, and who has been in charge while successive British Inspectors of Agriculture have been on leave. It is worth noting the convenient location of the cow-sheds and dairy—a hundred and fifty yards from the inspector's house and on the way to his office.

STOCK

There are no local cattle, and foundation stock was selected by the district authorities in Rumbek, some two hundred miles to the north, at the southern edge of the Dinka cattle country, from native cattle taken as fines—and it is fair to assume that the Dinka do not surrender as fines their best available animals.

Eleven cows were brought in during 1941 and 1942, 17 more in 1943 and 1944 and a further six in 1945 and 1946. In addition, 39 heifer and 34 bull calves have been born at Meridi. Stock bulls from Rumbek of unknown parentage were used at first, but the present bull is the son of the first stock bull out of a Meridi cow which averaged over a gallon a day throughout her first 431-day lactation.

FOOD

The cow-sheds are surrounded by fairly open, undulating country supporting natural pasture and scattered scrub. Predominant grasses are spear-grass (*Imperata cylindrica*), elephant grass (*Pennisetum spp.*), Guinea grass (*Panicum maximum*) and couch (*Cynodon dactylon*). In normal years there is good grazing for at least nine months, but cut green grass is fed in very dry weather. There is an unlimited supply of cotton seed from Meridi ginning factory, and cows in milk are given two pounds at each milking, together with two pounds of crushed millet.

HEALTH

Of 111 animals born or imported into the herd 75 remain. Nineteen unwanted males or unproductive females have been sold or slaughtered. The remaining 17 died for the following reasons:—Seven from trypanosomiasis; five from unknown causes, in some cases possibly "fly"; one cow from hoven followed by her calf; one calf from burns after falling in a fire; a second calf after its mother had developed mastitis (the only case to date); and a third calf from an undiagnosed stomach ailment.

Trypanosomiasis is the most feared disease and cows periodically go down with clear symptoms of it, although it has not always been possible to identify the trypanosome in blood slides taken. Animals which appear to have "fly" are given courses of antimony tartrate, intravenously injected, with excellent results in a good proportion of cases.

Meridi is the centre of a fairly closely settled district in which there is little thick bush or forest and in which game is scarce. The cattle have never been confined in wired sheds, but are given some protection by smudge fires both in their sheds and when tethered outside in fine weather. The herdsmen have been instructed from the start not to allow the cattle to graze outside a limited area, as far as possible from the Meridi river and from the thicker bush where *Glossina* is common. Fencing has recently been put up to ensure that cattle do not stray.

It is impossible to prevent animals brought in from Rumbek on the hoof from picking up "fly" on the way, and it is hoped that no further importations of cows into the herd will be necessary. The chief local sources of infection are the few sheep and goats kept in Meridi, and the cattle which are sometimes brought in for slaughter. It has been arranged that such cattle should be brought by a circuitous route and kept isolated at the place of slaughter which is some distance from the dairy herd's grazing ground. It is of interest that the only cases of "fly" during the past year occurred after these regulations had been disregarded by the local butcher.

There have been eight cases of abortion in the herd as compared with 73 live births, and it is probable that at least half of these have resulted from "fly" infection.

Every animal over six months old has been annually injected against rinderpest and contagious bovine pleuro-pneumonia, and there has been no case of either of these diseases.

BREEDING

The bull always runs with the herd and no attempt is made to "stagger" service dates, but the seasonal distribution of calving has been very convenient. The following figures show the calving months of the 73 calves born alive:—

January: 5; February: 2; March: 7; April: 1; May: 6; June: 8; July: 5; August: 8; September: 11; October: 10; November: 3; December: 7.

Calving, like the rains which extend from March to November with occasional rain even in the dry months, is much less seasonal than in the Northern Sudan (J. W. Hewison: "Dairy Farming in the Northern Sudan", *East African Agricultural Journal,* Vol. XI, No. 2), where cows all tend to calve just before or during the very short rainy season.

The records of nine cows which have been in the herd for several years (Table I) show that they have completed at Meridi 27 breeding cycles from calving to calving, averaging 250 days in milk and 150 days dry. Allowing 285 days for gestation, this implies an average service period of 115 days. Only in very exceptional cases has a cow been dried off in order to allow sufficient rest before the next calving. The lactation period is similar to that recorded at Shendi, but Hewison implies a much shorter service period and therefore a much shorter dry period at Shendi than is the rule at Meridi.

An interesting parallel is provided in the article "Observations on the Reproduction of Zebu Cattle in Southern Nigerian Dairies", by P. H. Richards, in "Tropical Agriculture", Vol. XXIII, No. 6. Cattle at the Shika stock farm in Northern Nigeria had an average service period of 83 days under fairly natural conditions, but the same stock, when brought south to Lagos and Ibadan, were very slow to come on heat. It was there thought that the long service period was due to the animals being kept in fly-proof sheds except for short spells of exercise.

It seems possible that fairly evenly spaced calving and the long service period at Meridi might alike be the result of well-distributed rains which provide grazing during most of the year. A clear seasonal division of the year into a time of plenty and a time of shortage may be necessary for cattle to breed in regular annual cycles. The fact that no such clear division occurs in many parts of the humid tropics may be an important obstacle to successful dairy farming in such regions.

MILKING TECHNIQUE

Calves are left with their dams for eight days and from then on are allowed to suckle for a few minutes before and after milking. On the one hand, this clearly cuts the recorded milk yields and, on the other, it must have contributed to the success in calf rearing. Cows are milked at 6 a.m. and 4 p.m. and the milk of each is at once measured into the strainer and recorded by the head cow-man on the monthly sheet. These records are all available from the starting of the herd, and a summary for the nine survivors of 11 cows originally imported in 1941 and 1942 is given in Table I.

MILK RECORDS

These nine cows have been the backbone of the herd and have produced 48,250 lb. of milk in 29 completed lactations, averaging 1,662 lb. per lactation and 6.5 lb. per day in milk. When selected from the fines herd all these cows were heifers and the Dinka could have had little idea of their potentialities.

The other 25 cows brought in from Rumbek between 1943 and 1946, of which only 10 remain, have between them completed only 21 lactations averaging 992 lb. per lactation and 4.2 lb. per day in milk. Most of these cows were of very poor type and had calved at least once before they were selected. One suspects that the Dinka recognized their limitations before surrendering them as fines.

Six home-bred cows, daughters of the 1941 and 1942 importations, have so far completed one lactation each, averaging 1,022 lb. at 3.9 lb. per day in milk. These figures are disappointingly low, even for first lactations, when compared with their mothers' yields, but it is hoped that the present stock bull will breed better milkers.

The whole herd has, in 56 completed lactations, produced 75,224 lb. of milk at an average of 1,340 lb. per lactation and 5.4 lb. per day in milk.

These yields are much lower than those obtained in the Northern Sudan (J. W. Hewison, *loc. cit.* and J. M. Boyns, "Sudanese Cattle as Milk Producers", *Empire Journal of Experimental Agriculture,* No. 57, Vol. XV). But it should be remembered that Meridi cattle were obtained from a "fines herd", and allowance must be made for the milk taken by calves at Meridi.

BUTTER-MAKING

The primary object of supplying Meridi's need for fresh milk is now easily achieved. Surplus milk is mechanically separated and the cream is stored in a refrigerator, each day's cream being added to the previous day's for between four days and a week. The ripened cream is then churned in a barrel churn very early in the morning when the temperature is normally between 60° F. and 70° F. The butter breaks after churning for half an hour to an hour, after which it is washed and salted. It then has to be returned to the refrigerator for an hour or two before it becomes hard enough to be shaped into pound blocks.

No analyses of butterfat have been made, but Table II shows the percentages of cream obtained from milk, of butter obtained from cream, and of butter obtained from milk in each of the past twelve months. The average monthly rainfall is also given, and it is noticeable that the percentages of cream and butter obtained from the milk drop very sharply during the driest weather. The percentage of butter obtained from milk varies between 2.79 at the height of the dry season and 4.38 in the middle of the rains.

SUMMARY AND CONCLUSIONS

After six years' experience at Meridi it seems that it should be possible to maintain the herd there without further importation of cows. This measure of success should be considered in the light of the following factors:—

(i) The herd has had particularly careful supervision from "foreigners" with a knowledge of cattle.

(ii) Meridi is in fairly closely settled country where game is scarce and there is not much thick bush.

(iii) Every effort is made to stop the cattle straying into thick bush or into areas where trypanosomiasis is likely to be picked up: fencing has been put up to ensure this.

(iv) The cattle have always been well fed.

(v) Animals which appeared to have contracted "fly" have always been given courses of antimony tartrate injections with generally good results.

Given conditions like those at Meridi, with careful management and unremitting supervision by staff who understand cattle, the keeping of a dairy herd in "fly" country should not be impossible.

The quality of cattle imported in different years into the Meridi herd showed great variation, but the nine cows which have been in the herd since 1941 and 1942 have averaged 1,662 lb. per lactation of 250 days, besides feeding their calves, while the average dry period has been 150 days. These cows were all obtained from a "fines herd", in which one would expect to find a large proportion of poor animals. The conclusion reached is that it should be easy to find cows capable of giving 200 gallons or over among the cattle of the Southern Nilotics.

Calvings have been very evenly distributed over the twelve months, although the bull runs with the herd. The average service period of 115 days is very long. Might not both these facts be related to the absence of well-marked seasons of plenty and of scarcity?

A method of making good butter is described. The percentage of butter obtained from the milk varied between 2.79 in the driest weather and 4.38 in the middle of the rains.

ACKNOWLEDGMENTS

The writer wishes to acknowledge his indebtedness to two previous Inspectors of Agriculture at Meridi—Mr. A. G. McCall, who started the herd and the system of recording, and Mr. R. G. Laing, from whom the writer took over. This article is largely an account of their work.

TABLE I

Milk Records of nine cows brought in during 1941 and 1942

Number	First Lactation				Second Lactation				Third Lactation				Fourth Lactation				Fifth Lactation		
	Total lb.	Days	lb./day	Days	lb.	Days	lb./days	Days dry	lb.	Days	lb./day	Days dry	lb.	Days	lb./day	Days dry	lb.	Days dry	lb./day
1	1,220	222	5·5	380	2,230	289	7·7	85	2,112	394	5·4	—	—	abor	tion	—	—	abor	tion
2	3,193	321	6·8	62	1,389	226	6·8	134	1,616	262	6·2	99	1,260	230	5·5	130	931	274	3.4
3	abort	ion	—	—	1,944	314	6·2	51	1,507	207	7·3	134	2,395	290	8·3	117	—	—	—
4	756	147	5·1	344	2,233	302	7·4	145	1,305	235	5·5	174	—	—	—	—	—	—	—
5	1,644	232	7·1	174	1,503	203	7·4	124	1,549	177	8·8	209	—	—	—	—	—	—	—
6	1,914	250	7·6	177	2,227	258	8·6	142	2,393	257	9·3	151	—	—	—	—	—	—	—
7	4,309	423	10·2	152	2,242	291	7·7	182	—	—	—	—	—	—	—	—	—	—	—
8	969	247	3·9	89	543	160	3·4	148	520	195	2·7	128	1,600	255	6·3	57	—	—	—
9	1,352	337	4·0	132	796	149	5·3	163	1,588	272	5·8	170	—	—	—	—	—	—	—
Aver.	1,795	273	6·6	189	1,679	244	6·9	130	1,574	250	6·3	152	1,752	258	6·8	—	—	—	—

		lbs.
Total yield for all complete lactations	.. .. ..	48,240
Average of all lactations	.. ..	1,662
Average daily milk yield of	.. ..	6·5

TABLE II

	Average rain in mm.	Milk	Cream		Butter			
		Taken for Cream	Total amount made	Expressed as percent. of milk	Taken for Butter	Total amount made	Expressed as percent. of Cream	Expressed as percent. of Milk
		lbs.	lbs.		lbs	lbs.		
November.. ..	68·0	897	81	9·23	62½	22	35·2	3·25
December ..	17·6	739	70½	9·54	52	21	40·4	3·85
January	11·2	930½	75½	8·11	61	21	34·4	2·79
February ..	35·0	1·216½	95½	7·85	87½	36	41·1	3·23
March	64·3	1,884½	168	8·91	157	58	36·9	3·29
April	174·1	1,798	173	9·62	168¾	65	37·3	3·59
May	195·4	1,316½	123½	9·38	116¾	44	37·7	3·54
June	170·6	1,097	102¾	9·37	96	39	40·6	3·80
July	181·8	1,068	103	9·64	105¾	46	43·5	4·19
August	182·9	866	86	9·93	78	33	42·3	4·20
September.. ..	147·2	1,074	108¼	10·10	110½	38	43·4	4·38
October	141·7	1,155	115	9·96	106	45	42·5	4·23
Total ..	1,389·8	14,024	1,302¾	9·29	1,201¾	476	39·6	3 68

THE PAPAW OR PAPAYA

By P. J. Greenway, Systematic Botanist, East African Agricultural Research Institute, Amani

(*Received for publication on 5th March,* 1948)

The genus *Carica*, to which the papaw or papaya *C. papaya L.* belongs, contains some twenty-two species, all of which are found in the warmer parts of America. Originally it was included by botanists in the families Passifloraceæ and Cucurbitaceæ, but it was transferred by the German botanist, H. Graf zu Solms, to the family Caricaceæ; he founded the family name on that of the generic name *Carica*. Besides *Carica* the family contains the genera *Jaracatia* found in America, and *Cylicomorpha* in Africa.

The names Papaw, Pawpaw, Papaya and Papita are applied to *Carica papaya*, those most commonly used being papaw and papaya. That of papaw is favoured by the Shorter Oxford English Dictionary, and was first used in 1598 being adopted from *papaya, papay* thought to be a corruption by the Spanish and Portuguese from the Carib word *ababai*. The use of the names papaw and pawpaw are confusing as they are also applied to a small North American tree, *Asimina triloba* (*L.*) Dunal of the Annonaceæ, which has a small edible fruit. Both these names appear to have been first used for this tree in 1760. It is of interest to note that the word papaya does not occur in the Shorter Oxford English Dictionary, neither does papaw in Sampson's "Cultivated Crop Plants of the British Empire and the Anglo-Egyptian Sudan".

In Swahili, the *lingua franca* of the East African coastal peoples, the Spanish and Portuguese name for the papaw has with a slight alteration in spelling, still been retained, *Mpapai* the tree, *papai* the fruit.

The exact home of the papaw in America is uncertain but it is nearly related to the "monkey's papay" *C. peltata* Hook. and Arn. of Mexico and Costa Rica, which is probably the female of *C. bourgeæi* Solms-Laub. It is possible that it appeared first in those parts of Central America where that species is found, but on the other hand it may have arisen through several hybridizations, some perhaps having occurred in Mexico.

BOTANY

Carica papaya (Fig. 1A) is a short-lived herbaceous tree up to about 30 ft. tall, usually with a hollow trunk and fleshy wood. It has no lateral branches, but frequently in age divides near the base into several erect stems bearing heads of leaves. The stem is grey, marked by large halfmoon-like leaf scars as the leaves only last one season, and it is crowned with a head of leaves not unlike a palm. The leaves are up to 2 ft. across, nearly orbicular in outline, usually palmately and deeply 7-lobed, each lobe pinnately lobed, pale green or glaucous beneath, dark green above with conspicuous venation. The cylindrical leaf stalks are hollow, 2 ft. or more long.

Sex Variations.

The tree is normally dioeceous, that is having male or female flowers on separate plants; it can also be monoecious, with both male flowers and female flowers on the same plant; there are also hermaphrodite types, with both sexes in the same flower (Fig. 1D and B) on the same plant.

In the male or staminate plant (Fig. 1C) the flowers are stalkless borne in clusters on long pendant racemes from the axils of the leaves; the corolla is tubular or somewhat funnel-shaped, about one inch long with five spreading twisted lanceolate lobes about half as long as the tube, creamy white or yellow in colour, fragrantly scented; there are ten stamens arranged in two series of five inserted on the throat of the corolla tube, the filaments are hairy, the anthers are oblong, two-celled with abundant pollen grains, oval in outline and yellow; pistal mostly rudimentary but occasionally in some flowers it is well developed and will develop into a fruit. The pollen is thought to be wind disseminated or by small insects like thrips.

In the female or carpellate plant (Fig. 1E) the flowers are shortly stalked and are borne along the upper part of the trunk, solitary or in few flowered corymbs in the axils of the leaves; there are five rudimentary sepals; the corolla is about one inch long and is composed of five fleshy lanceolate and twisted distinct petals which can also be shortly united at the base; the ovary is large, globose or slightly cylindrical with the apex terminating in five sessile fan-shaped stigmas. The fruit (Fig. 1F) is a fleshy berry, oblong or nearly spherical, 3 to 20 inches long and may weigh from a few ounces to 20 lb., with a thin greenish-yellow to orange smooth skin, the flesh yellow, reddish-orange or orange 1–2 inches thick enclosing a five-angled cavity on the walls of which are borne numerous black or greyish wrinkled seeds (Fig. 1G), half the size of a pea, enclosed in a thin tough gelatinous aril. Female trees have been pollenated and set seeds in isolated localities 800 yards from the nearest male or staminate tree.

In the monoecious plant the female flowers are similar to the flowers in the female or carpellate plant, but the inflorescence consists of short flower clusters three to five inches long and composed of about six almost stalkless flowers, each inflorescence being produced solitary in each leaf axil. The flower is 1½ to 1¾ inches long, the corolla has a tubular base which widens into a globular shape and spreading into five thick fleshy recurved lobes ranging in colour from cream to yellow; there are ten stalkless anthers which are attached to the throat of the corolla near the base of the lobes. The fruits from such flowers are 12 to 18 inches long, are cucumber-shaped, and weigh from 3 to 10 lb.

In hermaphrodite plants there are eleven types of flowers, the following are some of the more important types:—

1. The ovary is cylindrical and well formed; the corolla tube elongated, with ten stamens in the throat of the corolla; fruit elongated, cylindrical and pointed at the apex, its length two to four times its width.

2. The ovary is lobed; the corolla tube much shortened, the lobes being divided to the base of the ovary; only five stamens with long filaments attached near the base of the ovary and resting in furrows between the lobes of the ovary; fruit resembling that produced on a female or carpellate tree.

3. Occurs comparatively rarely in hermaphrodite plants and is identical with the flowers borne on female or pistillate plants, fruit globose or spherical.

4. Irregular flowers in which one or more of the stigmatic lobes are aborted giving rise to an asymmetrical or gibbous fruit in which the corresponding placentas have failed to develop; the filaments of the stamens often become fused with the wall of the ovary and they also become thickened as the fruit develops contributing to its irregular shape.

5. Pure staminate flowers that are larger but at the same time identical with the staminate flowers of a male plant. The purely staminate flowers may be produced in the same flower cluster as the other types or form separate flower clusters.

The papaw has 9 gametic and 18 zygotic chromosomes.

Sex Changes.

Some of these forms are not constant in their sex characteristics, one assuming the role of another. The most primary change of sex which takes place is the appearance of hermaphrodite flowers on trees which had previously only produced male inflorescences. The conditions which bring about this change have been studied in Hawaii and it has been observed that the fruiting of a male tree takes place in cool climates outside the tropics or at high altitudes, whilst in tropical climates fruiting by the male tree seldom takes place.

It is claimed that female flowers can be induced to appear on a male tree by injury such as the removal of the terminal bud or the breaking of the roots of old male trees in transplanting. However, none of these methods of treatment unfailingly bring about the desired change. It has been suggested that male trees pass through cycles of development and are subject to a sex change only at certain times.

It is of interest to note that a complete change of a male tree to one wholly female with the fruits of the form of an ordinary dioecious papaw has been observed in Honolulu. This change was brought about by the removal of the leaves and head of a tree about two years old.

An authentic case of a change of sex from a female or carpellate tree to that of a male has not been recorded.

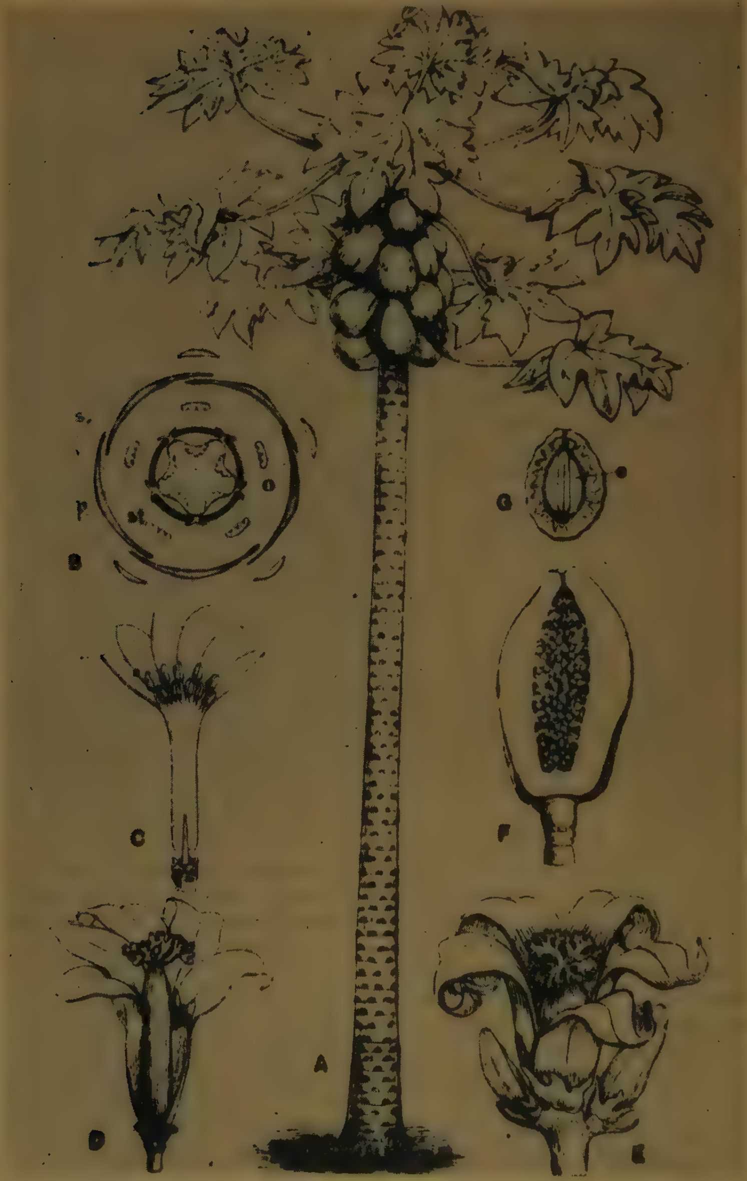
HISTORY

Carica papaya was first brought to the notice of Europeans by Oviendo (1478–1557), who was Director of Mines in Hispaniola from 1513 to 1525. He devoted a whole chapter to it in his *La Historia general y naturel de las Indias* and says that one Alphonso de Valverde had brought its seeds from the coasts beyond Panama to Darien, from there it was carried to San Domingo and to other islands in the West Indies. It seems that on the discovery of America it had not reached its possible limits of distribution in the New World although at that time it had become fairly well distributed on the mainland of tropical America.

The Spaniards carried the plant to Manila along with its Hispaniola name papaya which is still used in the Philippine Islands.

THE PAPAW OR PAPAYA

Carica papaya



A.—Female tree bearing fruit (much reduced).

B.—Diagram of bisexual flower.
(s, sepal; p, petal; st, stamen; o, ovary.)

C.—Male flower cut open.

D.—Bisexual flower cut open.

E.—Female flower.

F.—Young fruit cut open.

G.—Seed cut lengthwise showing median embryo and endosperm.

(Reproduced from A. B. Rendle's "The Classification of Flowering Plants", Vol. 2, p. 214 (1925), *by permission of Cambridge University Press.)*

Rumpf or Rumphius (1637–1702), a Governor of Amboyna, and a great botanical observer in his *Herbarium Amboinense*, between 1653 and 1692, states that every one agreed that either the Portuguese or the Spaniards had brought it to eastern Malaya.

The Dutch traveller, Linschoten (c. 1563–1611), after his visit to Goa between 1583 and 1589 wrote in his *Histoire Navigation* ed. of 1610, p. 145, that there was a fruit in Malacca called *papaios* which had been brought from the West Indies by way of the Philippines, so it appears that the fruit had not reached Goa between the years 1583 and 1589. Rheed (c. 1636–1691), the celebrated Dutch botanist and administrator, illustrates the papaw in his *Hortus Malabaricus* and the plate must have been drawn on the Malabar coast not long after 1667 when he became Governor of Ceylon.

Piso and Marcgrav, who were in the Dutch colonies in Brazil from 1637 to 1642, found it plentiful along the coast, the male plant everywhere in woods, the female not uncommon with it and plentifully in gardens (Marcgrav in *Histoire Naturel Brasil*, 1648, part 2, p. 102).

In Europe seeds of the papaw were brought from India to Naples in 1626 and there is a record of a plant growing there in the garden of a Dr. Schepanus in 1651. Commelin before 1686 had tried to grow the plant in Holland from seed sent to him from the West Indies. Germination of the seeds was good but the young plants only lived until the autumn when the frosts killed them.

Turning to East Africa, Laureiro (1715–1796), in the middle of the eighteenth century, saw the papaw in Zanzibar, and it is believed to have been brought by the Portuguese to East Africa in the sixteenth or seventeenth century. The possibility of its introduction into East Africa from Malaya by way of Madagascar should also not be overlooked. Grant, of the Speke and Grant Expedition, saw the papaw at Tabora early in 1861. The Arabs told him that its seeds were obtained from Maroongoa [*sic*] at the southern end of Lake Tanganyika. It was brought there probably by the Portuguese by way of Nyasaland or through the Luangwa River system from the Zambesi through Northern Rhodesia.

The papaw appears to have been well established in Uganda in 1874 because in that year Emin Pasha imported its seeds from Uganda into the Equatorial Province.

The papaw is now wild on a few small coral islands north of Mafia Island at the mouth of the Rufiji Delta and it is becoming wild in the Shiri River system in Nyasaland. The Mountain Papaw, *C. candamarcensis* Hook., too, is becoming naturalized in the West Usambaras, Tanganyika.

USES

The papaw is a common and popular fruit; the fruit as well as other parts of the plant contain a milky juice. This latex contains an active principle known as papain, an enzyme, which was first separated by Theodore Peckholt. It greatly resembles animal pepsin in its digestive action and has now become an important article of commerce, as it has a number of important industrial uses besides that of a digestive. The commercial product has a potency varying according to its process of preparation, etc., the usual grade digests about 35 times its weight of lean meat.

Papain is used to aid digestion in chronic dyspepsia and gastric fermentation. It is used externally as a solvent of false membranes on warts. It is applied as a 5 per cent solution in equal parts glycerine and water in diphtheria and croup; in a 15 per cent solution in fissured tongue; by injection in cancer. It is also used for tenderizing meats, for clearing beverages and for bating skins.

The whole plant has many native medicinal uses. The seeds and latex are used as a vermifuge, the seeds which contain a resin are more drastic in their action and they tend to produce abortion. The seeds are an emmenagogue and are also a counter-irritant.

The leaves when quite young can be eaten as spinach and the young fruits can be cooked and served as a substitute for vegetable marrow, or for apple sauce. In New Caledonia the leaves are used as a substitute for tobacco and in Mauritius are smoked for asthma. In Malaya and Java the flowers are used as a sweetmeat and as a food. In the East Indies the stem when the bark is removed is used as a famine food and the pith can be eaten raw.

Native Uses.

In East Africa the papaw has some uses to the African besides that of a fruit.

The roots are boiled in water and the liquid when cold drunk to expel round worms; an infusion of the root is made and taken thrice daily as a treatment for syphilis.

The leaves are used to tenderize meat; the young leaves are pounded and then cooked as a vegetable; the leaves are used as a soap substitute in washing clothes and are said to remove stains. The young fruit is used to cure an enlarged spleen, several incisions being made on the stomach and the young fruit is cut in two and bound in place. The latex is used to draw boils.

Composition of the Leaves, Fruits and Seeds.

In Malaya an analysis of the leaves (Rosedale and Milsum 1940) gave 83.3 per cent moisture; 1.4 per cent ash; 5.6 per cent protein; 0.4 per cent fat; 1.0 per cent fibre; 8.3 per cent carbohydrates; 0.406 per cent calcium oxide; 0.035 per cent magnesium; 0.115 per cent phosphoric oxide; 0.00636 per cent iron, vitamin C. mg/100g 38.6 per cent; carotene (expressed as Vitamin A) I.U/100 g. 28.900.

The following figures have been published (Popenoe 1924) on the composition of the papaw fruit of several different seedling strains grown at Honolulu.

Strain	Total Solids	Ash	Acids	Protein	Total Sugars	Fat	Fibre
	%	%	%	%	%	%	%
Trinidad	12·14	·53	·06	·43	9·72	·06	·78
South Africa	13·00	·54	·09	·68	10·73	·07	·81
Honolulu	12·20	·56	·07	·50	10·29	·05	·66
Barbados	11·72	·48	·06	·46	8·05	·06	·76
Panama	14·41	·90	·14	·50	11·12	·25	1·09

The sugar found in the papaw is principally invert sugar, only traces of sucrose being present.

The representative food values (Platt 1947) per 100 gms. of the edible portion of the fruit of the papaw is:—

Water content, range 85–94 g.; selected value 89 g.; calories 38; protein 0.6 g.; fat trace; carbohydrate 9 g.; calcium 10 mg.; iron 0.5 mg.; vitamins, A 2,500-c I.U.; aneurin 0.02 mg.; riboflavin 0.02 mg.; nicotinic acid 0.1 mg.; ascorbic acid 60 m.g.; waste 30 per cent of food as purchased.

In India an analysis of the seeds (Burkhill 1933) gave 26.3 per cent oil; 24.3 per cent albuminoids; 17 per cent fibre; 15.5 per cent carbohydrates; 8.8 per cent ash and 8.2 per cent water. The oil does not appear to have been investigated.

VEGETATIVE PROPAGATION

Besides growing from seeds, two methods of vegetative propagation of the papaw are possible, from cuttings and by grafting, but opinions differ as to whether these methods produce satisfactory plants. Cuttings are easily struck but they develop more slowly than seedlings. In the Dutch East Indies, budding has also been used, but no details of the method employed are available.

In grafted plants the growth is more rapid and they come into fruit early. At one time in America it was thought that grafting offered great possibilities because a surplus of male trees in a plantation could be replaced by grafts from female trees. Later experience, however, particularly in Florida, showed that by grafting a given variety degenerated rapidly, so much so that at the third or fourth generation from the parent plant the grafted plants grew very slowly and the fruits were much reduced in size and of poor quality.

Two methods of grafting are employed:—

In Florida an old tree is topped which causes shoot development from the buds at the old leaf scars, and from these shoots scions are taken. These are a few inches long and the diameter of a lead pencil, the base being cut to a wedge point and the young leaves reduced. The scion is grafted on to the stock, this being a young seedling which has the apical portion of the stem removed when it is five to ten inches high. The stem is split with a thin sharp grafting knife and the scion inserted into the cleft and tied in position. This work is done in greenhouses where the temperature and moisture can be properly controlled. When the scion has taken, the grafted plants are planted out of doors where they grow rapidly and begin to bear in nine or ten months from grafting.

In Queensland the method is slightly different, the scions are the side shoots from a young decapitated tree, about six to eight inches long, the best being those with a small hard knob at the base. The scions from an old tree produce trees which from the beginning have very indifferent vigour and should therefore not be used. The stocks used are those which have reached a diameter of stem between 1½ and 2½ inches, at a stage when the first flowers begin to appear when their sex can be determined.

The leaves are removed from the scions leaving a short stub of the leaf stalk, these are then rinsed in a strong solution of potassium permanganate and kept wrapped in a cloth wrung out in it. The permanganate appears to hasten callousing and stops the flow of latex.

With the stock trees, stakes are driven in to the ground as close as possible to the trees without injury, one stake per tree being used. The crown of the tree is then fastened to the stake to prevent movement. At about six inches from the ground a transverse cut is made three-quarters of the way through the stem, at this point the stems are solid. At about ten inches above this cut a deep slice is removed from the stem. All cut surfaces with the exception of the grafting surfaces are then swabbed with potassium permanganate. A cleft is then made in the step formed by the removal of a slice of the stem, this is made as close as possible to the upright portion of the stem. The scions are then cut wedged-shaped like a normal cleft graft and the cleft and wedge slightly shaped to prevent undue pressure when the scion is inserted in the stock. The stock and scion are bound with raffia and mounded up with moist sandy soil until the tip of the scion is just covered. The crown is left standing to maintain a flow of sap past the graft and to stop die-back.

The mounded soil is carefully removed from the graft after about fourteen days when it will be found that the raffia has rotted and the graft either taken or failed. If the graft has been successful the soil is gently mounded around it again.

After a further fourteen days, growth should be well under way after which the standing part of the stock is cut off level with the union between stock and scion; the graft is kept covered with soil for a time to hasten a complete union between stock and scion and to protect it from the heat of the sun.

This type of grafting resembles inarching, the difference being that the scion is removed completely from its parent plant.

For this type of grafting a very keen, thin-bladed knife is required for the grafting cuts and a stronger knife for preparing the stock, raffia is also needed Moist earth heaped around the graft helps the papaw tissues to callus rapidly, otherwise the cut surfaces would soon be dried out and the graft would fail.

It is claimed that this type of graft has proved successful in Queensland and the results approach 100 per cent of takes, a very strong union resulting.

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THE ESTABLISHMENT AND RUNNING OF A PAPAW PLANTATION

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The preparation of this section has for certain reasons devolved upon the present writer, who wishes, however, to acknowledge much information given by Mr. J. V. R. Brown, Senior Agricultural Officer, Moshi, Mr. J. K. Robertson, Agricultural Officer, Arusha, and Mr. A. Ghikas of Narumu Estate, Moshi.

The subject of papaw cultivation and papain production has already been described in this journal by Sanders and Robertson [3], and some of the information below has been taken from their statements.

The papaw is a common and popular fruit, but in recent years it has also become an important plantation crop on account of the papain obtained from the latex in the fruit. The crop is now well established in the Northern Province of Tanganyika Territory, and to a less extent in other parts of East Africa. It is essentially a non-native crop, and does not lend itself to cultivation by Africans, chiefly on account of the care required, but also because of the necessity for flue-drying.

Papaws were first grown for latex in Tanganyika in the late twenties, but it was not until the late thirties that their cultivation became extensive. The output from the territory for the period September, 1946, to August, 1947, was 2,573 cwt., valued at £353,851. The high price for the product was the chief incentive to the industry; this reached a maximum of Sh. 30 per pound in 1947. A fall in price in the latter half of 1947 to Sh. 21 per pound caused a slowing down in the planting of new fields. The crop suffered during the past year from unfavourable weather, and a repetition of this in 1948 would discourage many growers; that is, however, considered to be unlikely.

The establishment of a papaw plantation makes considerable calls on labour, but while high prices have been the rule, sufficiently high wages have been paid to attract the labour force required. As regards the outlook for this crop, the most important factor would appear to be the price of the product. Such factors as markets, weather, labour, pests and diseases are most unlikely to affect the maintenance of a considerable acreage under the crop in East Africa. Growers are becoming increasingly aware of the importance of care in the choice of sites, the maintenance of fertility of the soil and of keeping up the high quality of the product.

CLIMATIC AND SOIL REQUIREMENTS

The site for a papaw plantation should be chosen where the climate is warm, and certainly well below the frost line. Preferably the land should have a slight slope. The fields should be sheltered from cold or drying winds, by shelter belts if necessary, but stagnant air should be avoided. Wind-blown sand is destructive in South Africa, and this danger might well be kept in mind here.

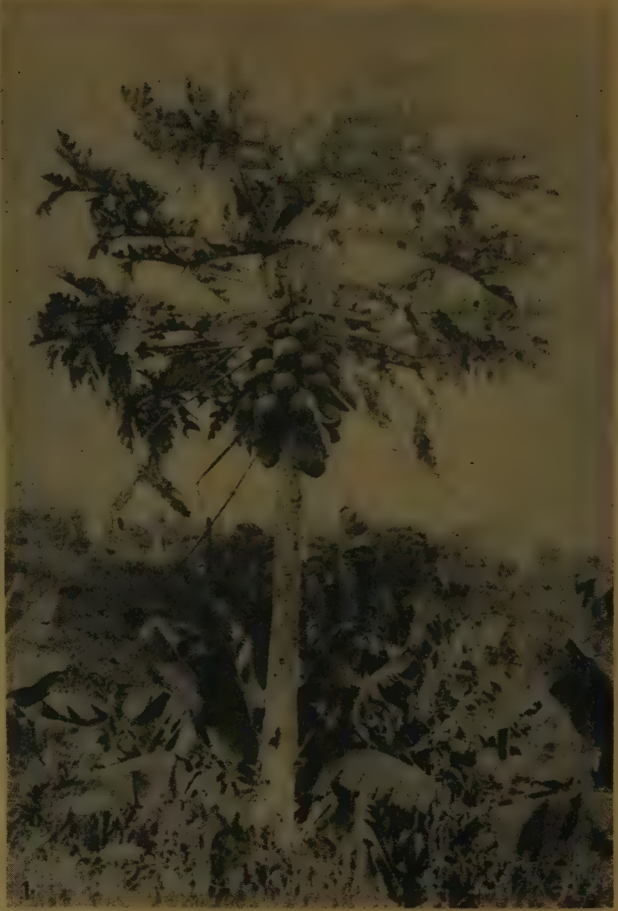
So far as temperature and sunshine are concerned, a large area of East Africa is suited to the cultivation of the crop. Above 4,500 feet altitude conditions may be unfavourable, and unless there is local experience caution will be required in planting.

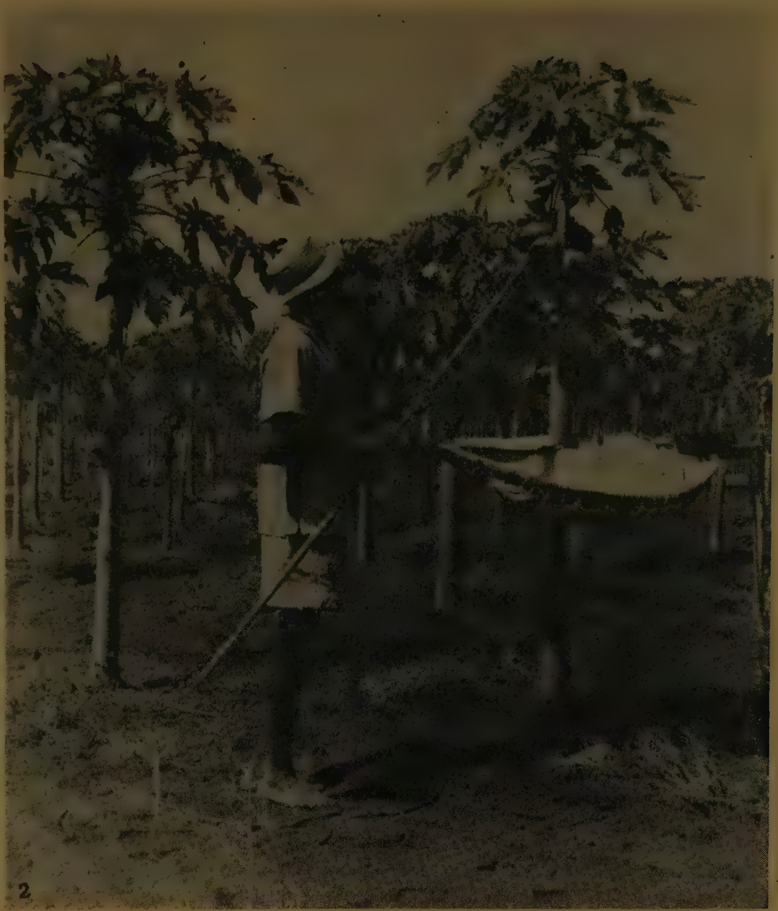
A water supply is necessary; in many parts rainfall is more than adequate for a considerable part of the year. As an example, on a plantation at 4,200 feet and having forty inches of rain in April–May, there was sufficient water in the soil after the rains to last until October or November. But, particularly in the lower drier areas, irrigation is required in the dry months. Water is necessary both for the establishment of seedlings, for the steady growth of the trees, and for the production of latex.

Excess water, either as rain or irrigation water, can be harmful, and in seedlings can encourage too fast and spindly growth. Stagnant water in the soil can very easily dispose the trees to root rot, apart from encouraging noxious weeds. A long rainy season, such as occurred in 1947, not only results in excess water, but may be accompanied by cold and insufficient sunshine. On the other hand, a dry period and inadequate water results in tapered stems, with reduced foliage, fruiting and latex production.

The physical and chemical conditions of the soil are very important. The first essential is

THE ESTABLISHMENT AND RUNNING OF A PAPAW PLANTATION

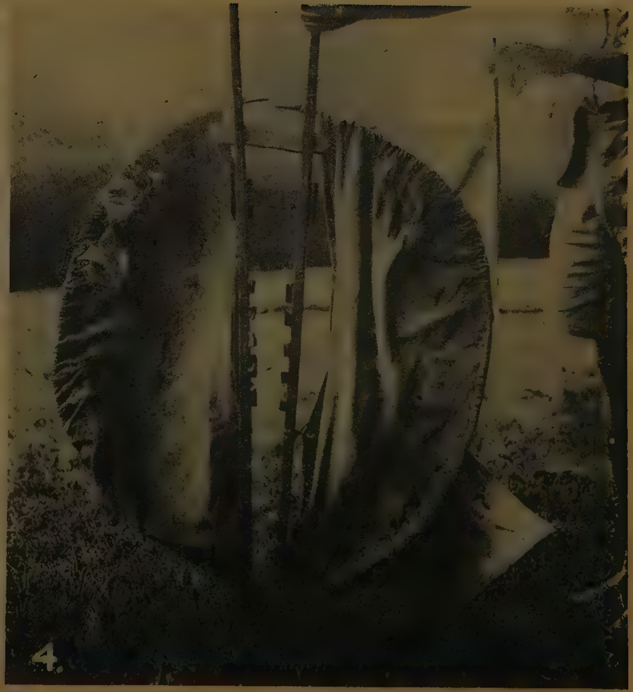




1. Papaw tree in native plot.

2. Papaw tapping (tree on left is a male).

THE ESTABLISHMENT AND RUNNING OF A PAPAW PLANTATION



3. Cut-back papaw trees with new shoots and on left unthinned seedlings.

4. Papain umbrella.

that the soil should be fairly open and deep; a fair proportion of sand or gravel is an advantage. The sub-soil must be such that free drainage and aeration are encouraged. Secondly, the soil must be rich in plant food, as the papaw is an exhausting crop; a good loam which has not been exhausted (e.g. by a succession of maize crops) is ideal. Black cotton soils can be productive, but in such there is a danger of stagnant water, and they should be avoided if possible.

Manuring is a subject which has not received much attention in East Africa, and in the absence of such information the recorded experience from other countries is given below as a guide. The actual chemicals required here will depend upon soil analyses. It is known that the papaw will respond to manurial treatment. Where manures are not available, more attention might be given to the choice of sites and to the use of cover crops.

In Queensland [1] favourable growth response in young plants up to fifteen weeks old was obtained from the use of organic fertilizers, particularly dried blood. Plants receiving no lime showed chlorotic symptoms and dropped their lower leaves prematurely, leaving an umbrella top, whereas 100 per cent increase in height was obtained during the first 21 weeks by the application of hydrated lime at the rate of four tons per acre. The author states: "It is considered that the following fertilizer measures will prove satisfactory in most instances: A NPK 8-12-6 mixture applied at the following rates per tree—(1) 4 oz. for trees up to three months old; (2) 12 oz. for trees up to six months old; (3) 2–3 lb. for trees from one year old upwards. The fertilizer is given in three or four applications during the growing and blossoming period. On depleted soils a basal dressing at the time of planting is to be recommended". It is stated that hydrated lime as an initial application, broadcast at the rate of 3–4 tons per acre should be beneficial, particularly on soils with pH below 5.5. It is also stated that plants should respond well to mulching with dry grass hay, cowpea hay, or other litter.

In South Africa [2] it is recommended that nitrogenous manures should be given to the trees when they become established, and again a few months later; in addition to five tons of kraal manure and 3 or 3½ cwt. of superphosphate per acre. Other more readily available phosphates should be equally effective.

ESTABLISHMENT OF A PLANTATION

Propagation is by seed, and these should be taken from untapped fruit of trees selected for the characters desired. Seed from tapped fruit is liable to be undeveloped and infertile, while seed from unselected trees may give undesirable plants or an excess of males.

Papaws are cross-pollinated and this has resulted in very variable types. It should be the aim of the grower to build up a suitable strain by selection, and endeavour to improve upon it in each generation. This is a subject requiring more study. Among the points to be borne in mind in selecting trees for seed are vigour of the trees, medium size of the fruit and sufficient spacing of the latter on the stem; also, dark and rough fruit are said to be associated with high quality of latex.

Seed may be sown in seed beds or directly in the field. In either case not less than six seedlings are required at each stake in the field, and these are thinned to one when the sex can be determined in the flowers. One male is required for the fertilization of from twenty to fifty females. The seed rate will depend largely upon a knowledge of the origin of the seed. Planting distance in the field is not less than seven feet. Where mechanical cultivation is possible a space of ten feet permits inter-row cultivation to be done by tractor without risk of damage to the plants. Inter-row cultivation is generally done by disc harrow, and as the papaw plant is normally deep-rooted there is little risk of damage to the roots.

Sowing at stake has the advantage that the seedling roots are not disturbed, and in a fairly light soil will grow out in a natural manner. This is essential if they are to exploit the available ground. The stand is more even than in transplants, and fruit will form more evenly. The risks attendant on transplanting from seed beds are injury or drying of the roots, twisting of the roots, and planting at the wrong level in the field. Sowing at stake is more expensive because of the care required in watering, shading and weeding.

A much higher seed rate than six at a stake is often necessary, and replacements may be required from a nursery, as there will be failures or losses from a number of causes. Examples of these are excess males, low germination, damage by moles or cut-worms, and injuries during weeding and rotting of the seedlings in wet weather. It will be clear, therefore, that whether or not planting is done at stake, a nursery will be required.

Seed beds should be chosen in a free-draining soil where flooding is not possible, and sited near a water supply. The beds should be raised a few inches above the surrounding ground level. They should be three feet wide. Seed is sown in the nursery three months before planting out. Planting out is best done in the second half of the rainy season; if done earlier there is a considerable danger of loss through water-logging and rotting. The time of sowing would, therefore, be arranged to allow of planting at the best time. Sowing at stake can be done at any time, but if at the beginning of the rains, the plants respond to the warmth at that season; if done in the cold weather growth is slow.

The seed is sown at a half-inch depth, spaced at one inch in shallow drills several inches apart, and covered with sand. The seed bed should be heavily watered before sowing to ensure an adequate water supply to the seeds and seedlings. If the seed is soaked for a week before sowing seedlings will appear in about ten days, otherwise there will be an interval of about twenty-one days. The beds should be shaded, but the aim should be to give no more shade than is necessary, and it should be reduced in overcast weather, otherwise the trees will grow long and thin. It must be kept in mind that the papaw loves sunshine and warmth.

Subsequent watering should be done in the early morning or in the evening; it must not be excessive or damping-off may be encouraged. Watering at weekly intervals in the early stages of growth, and fortnightly after the plants are six inches high, may be adequate. The shade is reduced gradually until the seedlings are six inches high, at which height they can be planted out.

Before taking up the plants the foliage should be reduced and the beds watered. They are taken up with mud attached to the roots or, better still, with a ball of soil, and should be protected immediately from sun and drying air. Those which have made poor growth or which have developed twisted roots should be destroyed.

Instead of sowing seed, old trees can be regenerated by being cut back to about a foot above a strong bud or shoot or to about eighteen inches above ground level. This procedure has, however, certain disadvantages: the growth is uneven in a field, and the side shoots are rather easily broken off where they leave the main stem; there may be difficulty later in attaching the papain "umbrella" to a sloping shoot or to get it directly below the tapped fruit. On the other hand, advantages of cutting back are that the sex of the trees is known; there is a saving of the expense involved in establishing seedlings; also, the time which will elapse before a new fruiting cycle commences is reduced. Whether these advantages will outweigh the disadvantages still remains to be proved.

In the Field

When the land is cleared it should be well ploughed and disced. If trees have previously occupied the site, the roots should be grubbed out, otherwise Armillaria root rot may be troublesome.

Lines are laid out on the contour if the land is sloping, and stakes are placed at seven or eight feet apart to mark the planting sites. For transplants, holes are dug a few months before planting, and left open until a few weeks before. Each hole should be about two feet deep and two feet across. Before the soil is returned a quantity of compost and about a quarter pound of phosphatic manure should be incorporated with it. On a light or well cultivated soil seedlings can be grown successfully without holes being prepared.

Transplanting should be done in cool, wet weather; on a dry day the ground will require to be well watered. Seed or transplants are placed a few inches apart, and shaded with bracken, banana trash, etc.

After-care in the field consists of carefully controlled irrigation, manuring where possible and keeping down weeds either completely or by slashing. Cover crops such as beans or sunn hemp can be grown after the first year, but during the first year they have the disadvantage of harbouring cutworm and rendering the collection of these difficult. A case is known of interplanted beans smothering young papaws during an absence of the grower. Care is necessary in weeding to avoid injury to the roots and stems, as disease organisms readily enter wounds. Irrigation should be done no more often than is necessary.

Cutworm can be extremely troublesome, especially in areas of high rainfall or in wet weather. An effective remedy is the use of Gammexane products with a suitable diluent to cheapen the treatment. Forms found suitable are Agrocide 1 or 2 in wheat bran. The mixture is moistened with water, and a dessert-spoonful is spread round each clump of seedlings planted out in the field or, in the case of nursery beds, uniformly broadcast; it

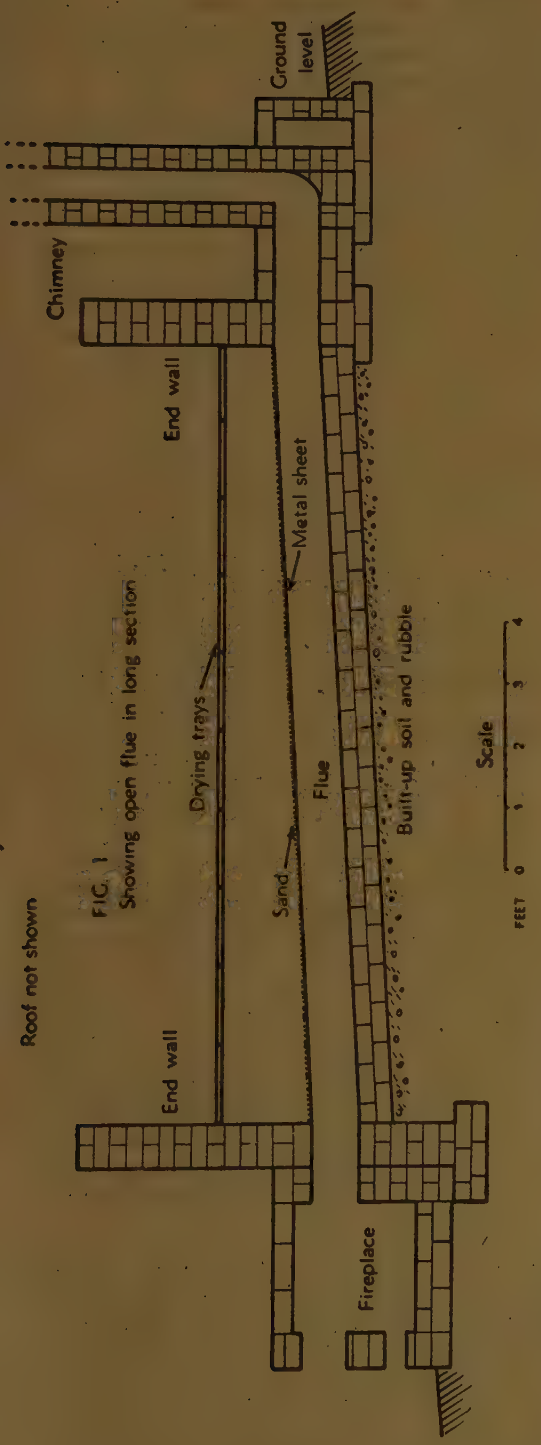


FIG. 1
Showing open flue in long section

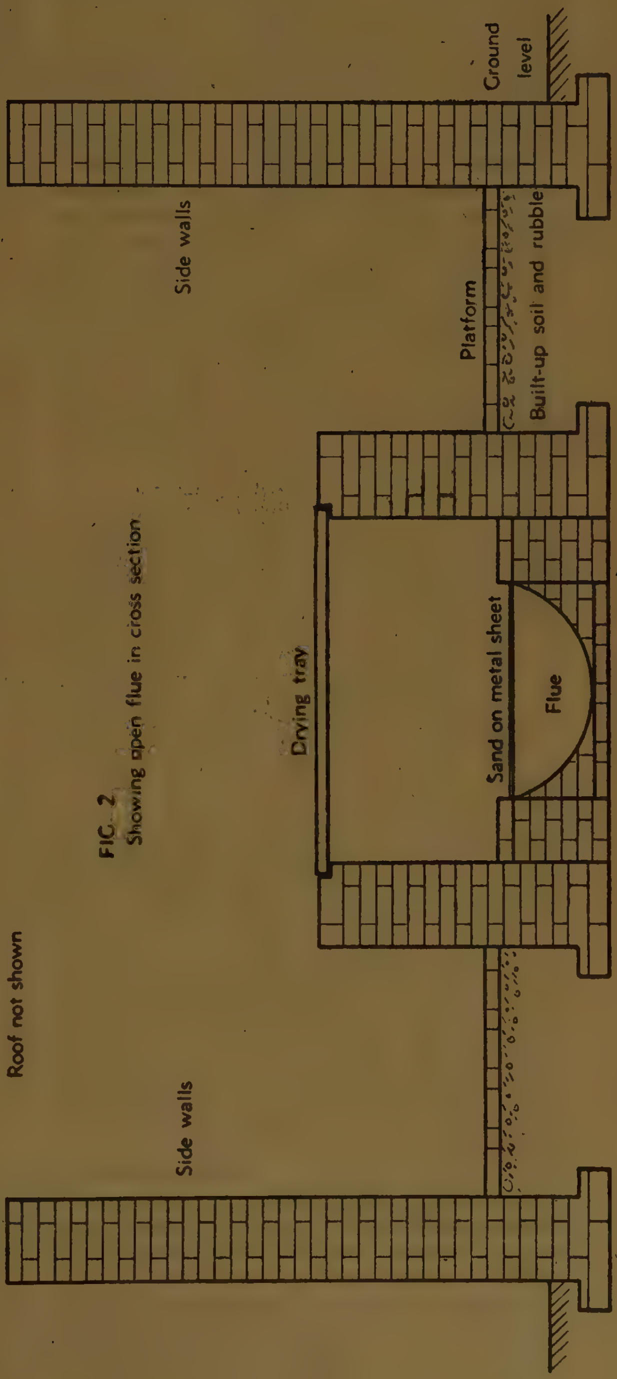


FIG. 2
Showing open flue in cross section

PAPAW DRYING SHED

is broadcast round mature trees when attacked and worked in to a depth of not more than two inches. It is best applied after rain or heavy irrigation, otherwise it is removed too quickly. In the case of a heavy attack it might be best applied before and again after rains. The effect can last up to a year, and it has proved more effective than Paris Green or D.D.T.

PAPAIN

Papain is dried latex and this is obtained from the green papaw fruit when the skin is cut or scratched. Trees are tapped until they are three or four years old, that is until the tops become small and unproductive and fruit are borne at too great a height for convenience in tapping. Tapping can commence when the fruit are about four inches in diameter, that is when the tree is some nine to twelve months old, as occurs at elevations of 2,000 to 3,000 feet and about 4,000 feet respectively. At the latter elevations latex will be in full production by about the fifteenth month. The flow of latex is low in hot sunshine and when the air is dry. Tapping is therefore done for preference in cool, cloudy weather or in the early hours of the morning. In favoured areas, that is at lower elevations, tapping may be done in most months of the year, but at higher elevations it continues for only eight months. The trees appear to respond to a rest from tapping, and the labour can be profitably spent in cleaning up the trees, removing dead leaves and ripe fruit, weeding, etc.

Ideally the cuts on the fruit should be made with a bone or aluminium blade, but the usual practice is to use a safety razor blade. This is set into a piece of hard rubber, usually a piece of old tyre, and this is attached to a stick of suitable length. The blade is allowed to protrude for one-eighth inch only, but it is likely that one-sixteenth inch would be sufficient. Deep cuts readily become clogged with latex and the wound is apt to remain open and become infected with decay organisms. Latex production is at its height at the ends of the long and short rains.

The fruits are tapped at intervals of about a week; the optimum interval is a matter of tests under any set of conditions; too frequent tapping results in reduced yield. One cut is sufficient for the first tapping of a fruit, and it is increased to two or three as the fruit becomes older. The later cuts are spaced between the earlier ones; by the time the fruit is changing colour and drying up the cuts will be spaced at about a centimetre apart.

Each collector can deal with two trees at a time. He is provided with a blade on a stick, two trays or "umbrellas" as they are called, a wooden box with a sliding lid fitted with a handle and a wooden scraper. The fruit on trees near roads are sometimes wiped free of dust before tapping, e.g. with a wad of cotton or sisal waste, attached to a stick if necessary.

The collector's procedure is to clamp an umbrella on to the stem of the first tree, make the incisions on the fruits, and proceed to the second tree with which he deals likewise. He returns to the first tree and if the latex has ceased to drop, the umbrella is removed and attached to a third tree, and the other trees are dealt with in turn. The latex is scraped from the umbrellas at intervals and collected in the box. When full, this is taken to the drying shed, and along with others is emptied on to the drying trays. Latex will flow for a longer number of minutes on a cloudy day than when the air is dry. Latex which has dried on fruits within reach is usually scraped off with a wooden scraper on the following day. It is kept separate, dried, and marketed separately as low grade. Latex left on fruit which are out of reach of the scraper is brushed off with a wad of sisal waste attached to a pole and discarded.

The umbrella used in the field consists of two pieces of strong cotton supported by flexible wooden withies and held on either side of the tree by two wooden battens. These extend beyond the umbrellas at one end as handles; they are held in position by a piece of wood hinged by two nails, and they are held to the tree by a piece of elastic rubber such as old tyre tubing; each has a row of rubber blocks to prevent the bark of the tree being damaged and to give a grip.

Papain should at no time come in contact with metal, as this discolours and damages the product. Nor should it come in contact with the skin on account of its burning action. Papain should not be exposed to the air any longer than is necessary, otherwise it is oxidized and discoloured, and also it takes up moisture.

THE DRYING SHED

An "open" type of drying shed is illustrated diagrammatically in figs. 1 and 2. The choice of this particular drying shed for description was simply a matter of convenience; they vary greatly, and there is as yet no standard type. About a dozen drying trays are laid side by side over the flue. The latter is inclined at a slope of 5 per cent. A kiln thirty feet long and six feet wide can produce about sixty pounds of dry papain in a day, using one to one and a half cubic metres of firewood.

A closed type of kiln is not illustrated; it differs in having the trays in tiers, up among which the hot air passes. As the front is closed by doors there is some risk of over-heating and darkening of the papain.

The trays are about six feet long and three feet wide; the wooden frame supports a wire-netting of quarter inch mesh. Strong cotton sheeting is laid over the tray and overlaps the edges. Ventilation of the drying shed is necessary to keep down the humidity.

When it comes from the field it is usual to remove extraneous matter by pressing the latex through copper or wire gauze of 40 to 50 mesh.

During drying the temperature is maintained at between 90° and 100° F., and the latex is kept stirred by a wooden spade. The time taken for drying is variously given as five to seven hours, and four to twelve hours; the time will depend partly on the condition and type of firewood used. Drying is complete when the product is crumbly and not sticky. The dry papain is packed in new 4-gallon petrol tins. The latter are first coated inside with melted paraffin wax; sometimes grease-proof paper is used to line the tins. The exporters grade the product into three qualities according to the colour. A full tin weighs 32½ lb. with a net weight of 30 lb. papain. The air is withdrawn from the tin before it is sealed; the tins are packed in pairs in petrol boxes.

The grower usually weighs the papain before and after drying to obtain an idea of the concentration. The average weights after and before drying are one to seven; in young fruit and in the dry season the latex is more concentrated and the proportion may be one to five; in old fruit and in the rains it may be one to ten or 1 to fifteen.

An example of papain yields in the Northern Province, Tanganyika, is given by Sanders and Robertson [3]. In the first year the yield was 20 lb. papain per acre; in the second year it rose to 80–100 lb., but it fell in the three subsequent years to 60–80 lb., 40 lb., and finally 20 lb., a total of 240 lb. per acre for the five years.

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BOOK REVIEW

NUFFIELD COLLEGE READING LIST ON RURAL CONDITIONS AND BETTERMENT IN THE BRITISH COLONIES, by Philip Mayer. Published by Geoffrey Cumberledge at the Oxford University Press, 1947. Price 4/6d.

Over 1,100 references are given in this book of 121 pages, the nine main subject headings being: the agrarian system; agriculture, stock-rearing and fishing industry; agricultural marketing and credit; land tenure and land policy; land utilization; the preservation and reclamation of land; nutrition; rural education; and rural welfare.

In an introductory note, Miss Margery Perham mentions that this is one of a series of reading lists which are being issued for the use of general readers and members of the Colonial Service rather than for the specialist or the student. She also states that reading lists have been or are being prepared upon other aspects of colonial studies, including colonial administration, law and justice, colonial economics, and urban administration in Africa. Application for these should be made to the Oxford University Institute of Colonial Studies, 10 Bardwell Road, Oxford.

The book under review will be an asset to administrative and technical officers who are stationed some distance from a good library, and with the improved facilities for obtaining photographic reproductions of journal articles it should be possible to build up a compact library on one or two particular subjects without the expense of subscribing to a number of periodicals. In addition, the Colonial official, who is frequently transferred from one station to another, cannot easily transport numbers of books, and this reading list will assist him in choosing only those articles which are of direct interest. It is hoped that this list will be brought up to date frequently.

D.W.D.

DISEASES OF PAPAW AND THEIR CONTROL

By G. B. Wallace, B.Sc. (Agric.), Ph.D., Plant Pathologist, and Maud M. Wallace, M.Sc., Temporary Scientific Assistant, Department of Agriculture, Tanganyika

(Received for publication on 8th December, 1947)

Diseases of papaw have been described in the East African Agricultural Journal in 1944 [2] and in Circulars of the Tanganyika Department of Agriculture; the available information is combined in the present article.

It is considered that disease in papaw will seldom be a serious problem if attention is paid to the choice of site and to field operations such as planting and irrigation. The tree quickly responds to environment and culture. Parasitic fungi are often, although not always, associated with disease in the plant; they can be controlled by repeating spraying, but so far as possible they should be prevented.

Cultural conditions which encourage healthy growth have been dealt with in an article by one of us (G.B.W.) on cultivation of the crop [3].

SMALL HEADS

Reference must be made to a group of symptoms to which the above name can conveniently be given. They include: progressive diminution of the size of the leaves, short leaf-stalks, a tapering top to the stem, stoppage in flow of latex, sometimes cessation of flower formation, rapid leaf-fall and ultimate complete defoliation and death of the tree. These symptoms can be brought about by any of the following conditions: old age, stoppage in the flow of water and plant food to the leaves through drought, excess soil water, root disease, twisted roots, hard or poor soil, and more rarely by mosaic disease. If the symptoms in a field can be correlated with any of the above causes, it may be possible to decide what measures can be taken to remedy the conditions. In 1947 rather similar symptoms were common and were associated with unfavourable weather.

The following table lists the diseases of papaw recorded in East Africa and the parts of the tree attacked.

PYTHIUM ROOT ROT

(*Pythium* spp., including *P. aphanidermatum*)

The fungus associated with this disease cannot be seen except under the microscope. It is favoured by excessive moisture in the soil, consequent on heavy rain or over-irrigation or poor drainage. The absence of any obvious white and black fungus mycelium in diseased roots serves to exclude Armillaria as the cause of the rot: this is important since both the conditions for the appearance of the two diseases and the control measures are quite different. It is is possible for the roots to decay without being infected by parasites, but such cases cannot be diagnosed by eye, and therefore any doubtful roots should be removed.

PARASITIC DISEASES OF PAPAW

Disease and parasite	Parts of tree affected							
	Seedling roots	Seedling leaves	Roots	Lower stem	Upper stem	Leaves	Fruit	Flowers
Root rot								
(*Pythium*)	X		X	X				
(*Armillaria*)			X	X				
Mosaic (*virus*)						X		
Mildew								
(*Ovulariopsis*)						X		
(*Oidium*)		X				X		
Leaf and fruit spot (*Ascochyta*)					X	X	X	X
Fruit rot (*Phytophthora*)					X		X	
Anthracnose (*Glomerella*)							X	

Pythium is a soil-inhabiting fungus; its entry into the roots of papaw and other susceptible plants is facilitated if the roots or base of the stem are injured by hoes or cutlasses. A type of infection more difficult to prevent occurs when the fungus enters the stem above ground-level through the thin bark over old leaf-scars; such infection can be quite independent of any infection of the roots. The tissues below the break were healthy, but the fungus was found in the stem above. This type of infection results from wind-borne spores and possibly by splashing of infected soil in heavy showers. Infected roots have a disagreeable smell resulting from fermentation set up by secondary organisms.

Seedlings in the nursery can be affected, and in this case the disease, "damping-off", is encouraged by overcrowding and excessive humidity. Seedlings planted out in the field have been seen infected where the soil remained wet for a considerable time, e.g. when transplanting was done early in the rainy season. The stem at soil level becomes constricted and rotten, and water-soaked lines are seen running up the stem. The seedlings become shrunken, dried and sometimes flattened; the leaves wilt and the plant quickly dies.

In older trees infection of the roots results in these turning brown, soft, and rotten. The rot spreads upwards into the stem, more often on one side only. The tree endeavours to isolate the diseased tissue by the formation of callus, but rarely with success. Affected trees fall or can easily be pushed over. With the death of roots, or of the stem base leaves become progressively smaller, yellowed and they soon fall. A tree may be completely defoliated before it falls. The stem tends to bend away from the diseased side, and in the latter there can often be seen a longitudinal split, more or less callused over; the bark on that side is flat and may conceal the rotten tissues below. The split in the bark referred to above is not filled with a crust of black fungus mycelium as in the case of Armillaria.

In a deep or free-draining or stony soil, or on slopes, this disease is unlikely ever to reach serious proportions, but on flat land liable to flooding through heavy rain or by excessive irrigation, the disease has been seen to cause the death of practically all the trees in a field.

Control.

Seed-beds should be raised slightly above the general level of the ground; the soil should be deep and well cultivated to allow of drainage. Seed should not be sown too closely, and over-watering should be avoided. If damping-off appears in a seed-bed, affected plants should be removed and the beds watered with Cheshunt compound. The latter is prepared as follows: two ounces of copper sulphate and eleven ounces of ammonium carbonate are ground separately to fine powders. These powders are then thoroughly mixed dry and stored for at least twenty-four hours in a tightly stoppered glass or stone jar. For use, one ounce of the mixture is dissolved in a little hot water, and this is made up to two gallons with cold water. Both chemicals are obtainable locally.

In the field every effort should be made to avoid the disease by providing the conditions for healthy growth which have been indicated above and in the article dealing with cultivation. Injuries to the roots and the base of the stem should be avoided during cultivation and weeding.

In areas where infection through the old leaf-scars at the base of the stem is common, some growers paint the stem bases with lime to prevent infection, but results are inconclusive. Where the practice is adopted, it should be commenced at the first sign of the trouble.

As the parasite multiplies rapidly in affected roots and stems, these should be removed, split to hasten drying, and then burned. Weeds should be kept down to encourage dry conditions at soil level.

ARMILLARIA ROOT ROT

Armillaria mellea, in spite of its widespread occurrence, is rare in papaw trees and so far the only records are from Tanganyika. Here it has been seen on a few occasions. In one field it was seen in a few lines of papaw growing alongside an old stumped Grevillea avenue. In two other fields single trees near dead Grevillea roots were affected, while a papaw tree in a garden was infected from a dead Eucalyptus. In the first field some derelict coffee trees were equally open to infection but remained free of the disease, which indicates a relatively higher susceptibility of papaw. The paucity of the records of Armillaria in papaw is doubless accounted for by the fact that the tree has only been grown on a plantation scale here for a comparatively few years. The above cases occurred on Kilimanjaro where the soil is neutral in reaction and Armillaria uncommon; the disease could be expected to be more prevalent in papaws grown in more acid soils, which encourage the fungus.

In Armillaria root rot in papaw or any other host plant the fungus itself is very obvious to the naked eye. Vertical cracks can be seen in the bark at the base of the stem (as well as in the roots) and these are filled with a black frill or crust of hard compact fungus mycelium. When the affected part is split or cut across the tissues are seen to be brown and rotten; sheets of white mycelium are seen below the bark, and irregular patches of mycelium are seen scattered in the tissues. Except under wet conditions, the smell of the rotted tissues is not so disagreeable as in the case of other root rots of papaw. The symptoms of the disease in papaw are very similar to those seen in banana.

The black fungus strands, *rhizomorphs* or "boot laces", are not very common, but can sometimes be seen extending from affected roots into the neighbouring soil. In the first case mentioned above *rhizomorphs* were traced back through the soil from an infected papaw tree to an infected Grevillea root, thus showing the origin of the infection. Infection might also arise from pieces of root or wood in the soil. An infected papaw can be a source of danger to its neighbours. The uncommon mushroom-like fructifications of *A. mellea* have been seen once on a dead fallen papaw tree; spread of the disease by spores is not, however, thought to be common.

Control.

Care is necessary in establishing papaws on land cleared of trees, whether forest or shade trees, for example on old coffee land. All roots which are encountered when cultivating, and especially when digging pits preparatory to planting, should be removed carefully and burned.

Papaw trees found to be infected should be taken up completely and the source of the infection sought and dealt with. After removal of a tree, the hole should be left open for a few months; lime added to the holes will hasten decay of wood scraps, and will also benefit the replacements. Annual crops, which are not normally susceptible to Armillaria, can be grown on affected land.

MOSAIC

This disease of papaw is almost certainly caused by a virus. It appears to be rare in East Africa, but in other countries diseases of this type, recorded under various names, are more common and cause a considerable amount of loss. Such diseases have been recorded from the West Indies, Queensland, India, Java, Burma, China and Rhodesia. It is likely that there are different strains of the virus, and this would account for the different symptom expressions in the various accounts.

The symptoms of the disease observed in Tanganyika Territory do not agree fully with any of the descriptions from elsewhere, and even here they may not prove to be consistent. So far, however, the disease has been seen rarely in this country, and the loss caused by it is negligible, but a watch will require to be maintained for further cases. Mosaic was observed in a few trees at Mombasa by Mr. R. F. W. Nicholls, Assistant Plant Pathologist, Amani, in 1947.

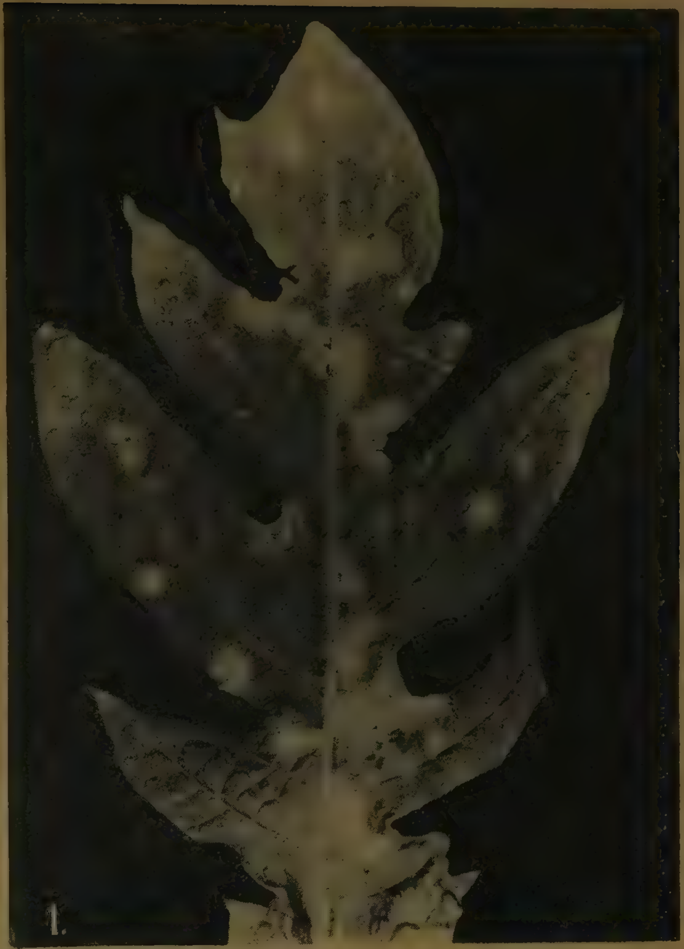
The symptoms noted in a recent case were as follows: the affected tree was not stunted and was actually taller than its neighbours. The stem was about fourteen feet high, rather lanky, and with a small crown of leaves some five feet in diameter—smaller than in the healthy neighbours. The crown leaves were about half normal size, leathery in texture, and they recalled fig leaves in their shape. By far the most affected leaves were those on side shoots, low on the main stem. These showed less segmentation than is usual; uneven growth resulted in lop-sided and distorted outline and some leaves were cupped downwards. The main veins had a narrow clear area on either side; many veins were twisted and the main veins sometimes bent together and united. The colour of the leaves was lighter than normal, and angular patches of dark green were limited in their outline by the smaller veins. Some leaves showed a yellow mottling. The fruits were restricted to about nine inches of stem about two feet below the crown: no flowers had been formed in recent months. The fruits were small, five inches long and three inches in diameter; they were yellow but surprisingly hard. No "oil-drop" spotting was seen on the petioles and stems, such as occurs in the papaw mosaic in Southern Rhodesia and Trinidad.

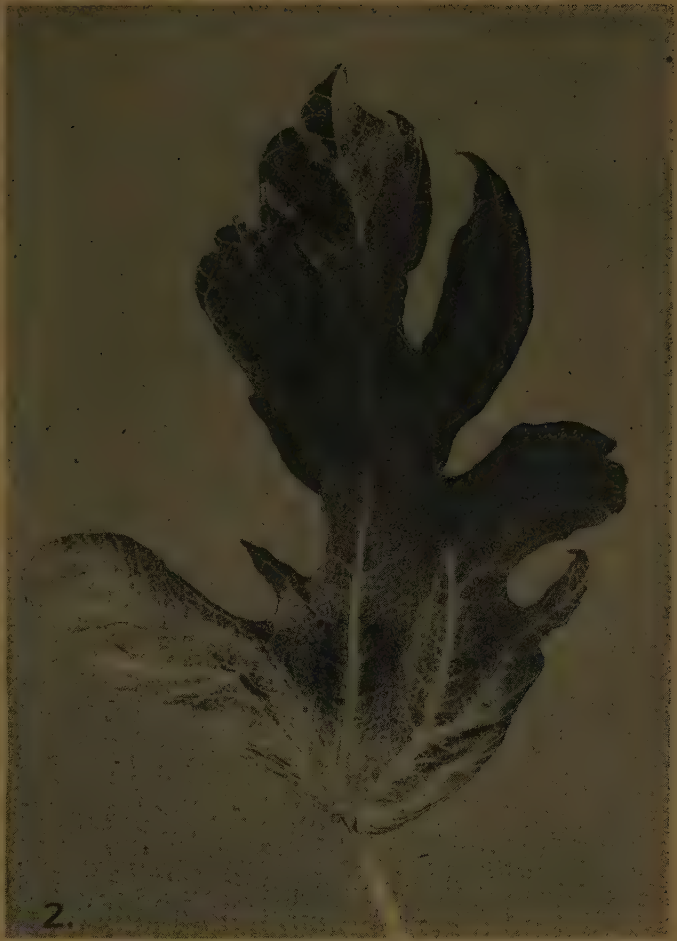
Control.

If, as appears to be the case, the disease is rare in East Africa, the best control will be to destroy diseased trees as they are seen. Should, however, the disease be found more common, other measures might be substituted, e.g. if the tops only were infected, cutting back at about four feet below the infected part might suffice; with side-shoots also affected, that procedure would be ineffective. So far no insect has been found to carry the disease, and the method of spread is unknown.

MILDEWS

Two mildews occur on papaw, *Oidium caricæ* and *Ovulariopsis papayæ*. The *Oidium* occurs most commonly on seedlings, but has been seen on trees up to a year old; it extends over the whole leaf. In Queensland it attacks the fruit also, causing blemishes. The





1. *Ovulariopsis* mildew on upper surface of papaw leaf.

2. Papaw leaf, 4½ inches long, showing some *Mosaic* symptoms.

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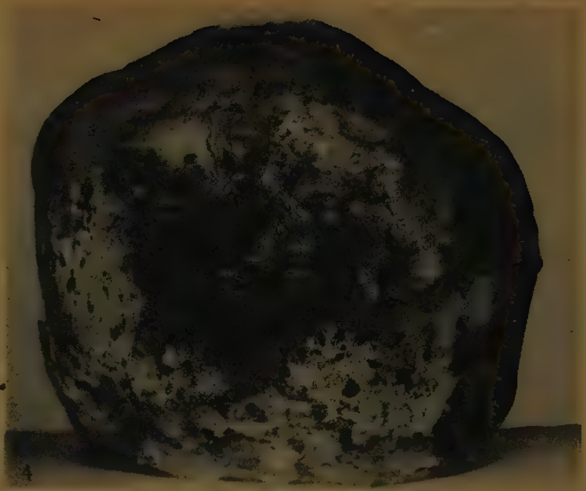
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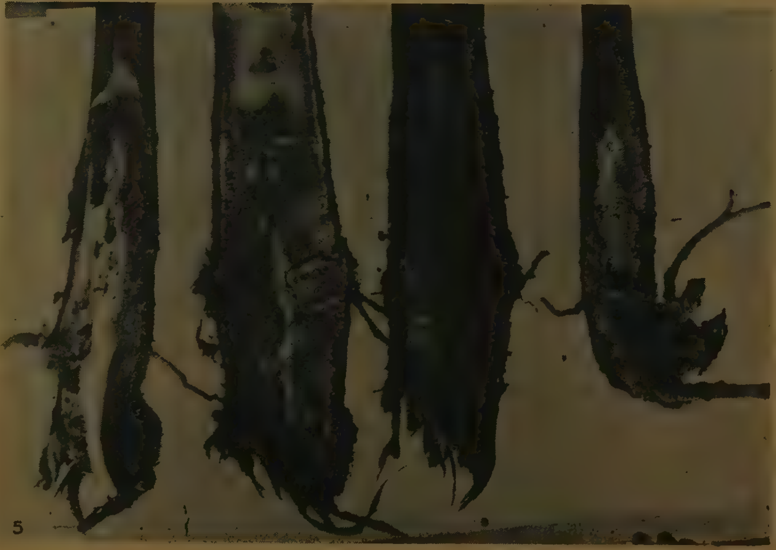
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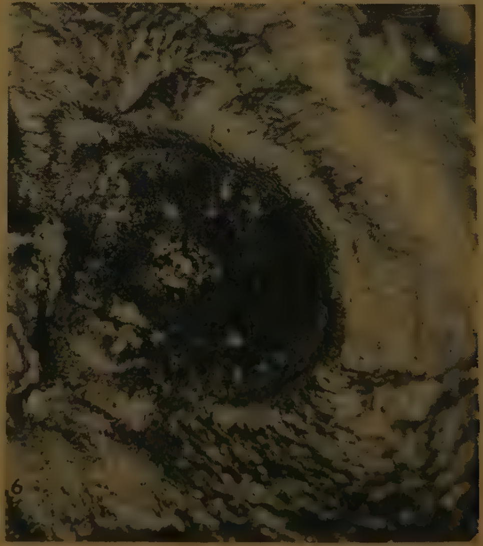
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3. Fallen papaw tree killed by Pythium root rot.

4. Base of papaw fruit with *Anthracnose*. (The pale areas were covered with red pores.)

5. Young papaw trees; two split to show *Armillaria* rot.

6. Part of papaw fruit with a black *Ascochyta* spot 1¼ inches long.

Ovulariopsis is the common mildew in older trees; it causes pale yellow spots on the leaves. In both mildews the superficial white spores can be seen. Both are encouraged by low temperatures and high humidity.

Control.

Close planting and excessive shelter should be avoided. Spraying or dusting might be undertaken, particularly in seed-beds. There is a choice of sprays, e.g. colloidal sulphur, wettable sulphur or lime-sulphur. For dusting, either dusting sulphur alone or mixed with hydrated lime can be used. It is necessary to treat the trees several times at intervals of about three or four weeks.

LEAF AND FRUIT SPOT

(*Ascochyta caricæ*)

This disease can attack all above-ground parts of the tree. In Tanganyika it has been seen on the fruit and leaves, and it is recorded on fruit in Kenya [1]. Specimens received from Uganda showed the disease in both stems and fruit. In Queensland the disease, under the name "Black spot", is said to be probably the most serious disease to which the papaw is subject in that country.

Symptoms are as follows: flowers may show brown decayed areas; fruits have round brown sunken areas which later turn black, and the rot spreads down towards the stalk, so that the fruit is killed; affected parts have many small black *pycnidia,* fructifications of the fungus, from which white tendrils of spores are exuded.

On the upper leaf surface the spots are brown with a rather darker margin, but sometimes they turn a chalky white as they dry out. The necrotic areas may crack and break away as they dry. On the lower surface the spots are slightly paler. The fruiting bodies can be seen on the leaves also, more easily with a pocket lens; they are mostly on the under-surface. The dried white parts of the spots can be distinguished from mildew spots which have an indefinite border and a layer of powdery spores.

Control.

Dead tops, and dead leaf-stalks which can be removed without injury to the fruit, and also diseased fruit and fallen leaves, should be collected and destroyed. Bordeaux mixture sprays are not safe for papaws since the young leaves can be scorched. Safe fungicides are lime-sulphur at one part in thirty-five parts of water, or cuprous oxide at 1¾ lb. to 40 gallons of water. Such will also assist in the control of mildew.

PHYTOPHTHORA FRUIT ROT

There are probably several species of *Phytophthora* responsible for disease in papaw fruit in this country, as is known to be the case elsewhere. *P. parasitica* is, however, the only species actually identified here. *Phytophthora,* like the *Pythium* causing root rot, requires damp conditions for its development and multiplication, so it is most common in wet weather and in damp places where there is little movement of air.

The fungus can be found both on fallen fruit and on fruit still on the trees. The same fungus can also penetrate the leaf-scars towards the top of the tree and spread up and down the stem, so reaching the new leaf-stalks or fruit-stalks causing leaves and fruits to fall. The disease may spread across the stem, rotting it and causing the top to fall over. Affected parts show water-soaked areas of a different shade of green from the healthy tissue, and the part becomes soft and rotted. In a humid atmosphere affected fruit show a thin felt of white fungus mycelium and spore-bearing organs.

Control.

So far as possible, there should be no hindrance to a free movement of air among the trees: there should be no dense wind-breaks to encourage stagnant air. Where the disease is serious it would be very advisable to collect fallen fruits and bury them. This would remove a considerable part of the sources of infection. Ripe fruits should be removed from the trees and also buried.

ANTHRACNOSE

(*Colletotrichum Gloeosporioides*)

This fungus is the most common cause of fruit spotting. It causes round, brown flat or sunken areas particularly on over-ripe fruit, and in damp weather the abundant pink spores of the fungus are diagnostic. The fungus lives on any dead parts such as leaves or leaf-stalks, as well as on ripe fruit. The disease is of most importance when fruit is grown for the market.

Control.

The sources of infection will be much reduced if ripe and fallen fruits are collected and buried in pits. The collection and burning of leaves and leaf-stalks would also destroy breeding places. Where the fruit are grown for tapping the disease should not be a problem, but if for ripe fruit it may be necessary to spray, e.g. with a cuprous oxide fungicide at a concentration of 1¼ lb. per 40 gallons of water. Soft soap should be added to give a good cover on the waxy fruit, at the rate of 2 lb. per 40 gallons of fungicide.

OBSERVATIONS ON A DISEASED CONDITION OF PAPAWS IN THE NORTHERN PROVINCE OF TANGANYIKA IN 1947.

The following notes are based upon a report made in August, 1947, after a survey of plantations. It is not unlikely that it may have some reference to conditions in Kenya also.

In the 1947 season there was an unusual trouble throughout the Northern Province affecting papaws in many fields. There was no evidence that it was caused by any parasitic organism, and its general distribution indicated that there was some cause common to all fields. It was reasoned that such could only be climatic. The recent weather had been abnormal, particularly the heavy and prolonged rain, and the lack of sunshine and warmth.

Symptoms.

The symptoms in the affected trees varied somewhat in different fields, but trees under one year old were suffering most; old trees on the same land were often normal.

Growth for most of the year was slow; the internodes on the stem and the leaf-stalks were short and the leaves small, which resulted in bunched foliage, pyramidal in shape. Healthy leaves which had been formed before the rains started about March stood out very much further than the affected leaves above. Leaf-fall was heavy and on many trees few or no leaves remained, while the stems tapered to a point. Such trees would not recover, unless possibly by being cut back to a new shoot. Leaves, apart from being small, were much crinkled, and were drying out, and had the appearance of suffering from cold or of being starved. There was no actual mottling except where mildew was present, but there was more or less yellowing of the leaves.

The flowers on many trees were not being formed or they soon died and fell. Where fruits were formed they were small and often dry. Latex production fell off seriously and was sometimes watery.

Discussion.

Considering the heavy rainfall, there was surprisingly little root rot, and the failure of the trees could not be referred to root disease. Deep planting or twisted roots could not account for the extensive damage, and where roots were taken up they were generally in good condition.

It was considered that several factors had been operating to affect the trees, e.g. heavy rain and consequent reduced nitrification in the soil would account for some of the yellowing in the leaves; plant foods would be washed out to some extent thus starving the leaves in proportion. Healthy growth in papaw is largely dependent on ample soil aeration and this is reduced where the soil is very wet.

Above ground, normal activity in the leaves would be reduced by the overcast weather and little sunshine, while cold drying winds would affect the normal growth and health of the leaves. The formation of normal flowers, fruit and latex is dependent on the general vigour of the tree.

There is admittedly a good deal of guesswork in accounting for the condition of the trees, but, in the opinion of the writer, weather, and to some extent changes in the soil conditions consequent to the weather, could account for the symptoms observed.

As regards the outcome, many of the still living trees would not survive. Where the tops of the stems were tapered and the foliage much reduced, it was most unlikely that normal growth would be resumed. Cutting back would, however, encourage new shoots particularly in older trees. Various cultural measures were recommended, but these have been adequately dealt with in the previous pages. It was also recommended that trees past recovery should be taken up, split and dried out and burned as soon as possible. With the resumption of more normal weather it was reasonable to expect that many trees would recover.

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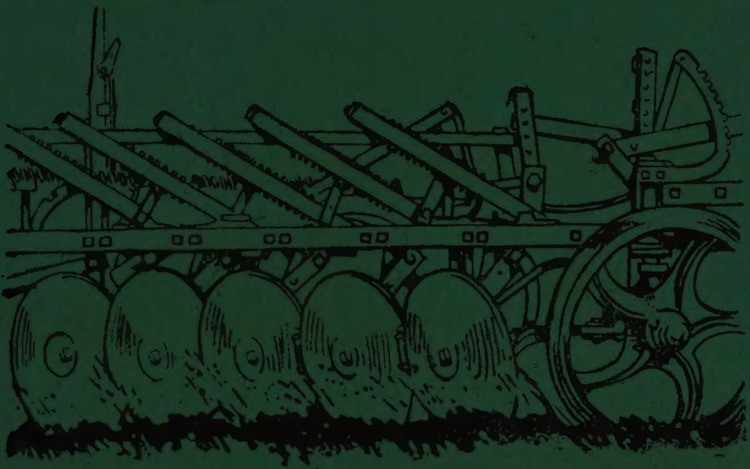

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